

Cyprus Foote Mineral

Draft Remedial Investigation/
Risk Assessment Report
Volume 1
*West Whiteland Township,
Pennsylvania*

10 November 1997

Environmental Resources Management
855 Springdale Drive
Exton, Pennsylvania 19341



PFE ORIGINAL

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10 November 1997
Reference: H2004.70.01

Mr. James Feeney
US Environmental Protection Agency
Region III 3HW22
841 Chestnut Building
Philadelphia PA 19107



Dear Mr. Feeney:

Environmental Resources Management (ERM) submits herewith three copies of the document titled *DRAFT Remedial Investigation/Risk Assessment Report, Cyprus Foote Mineral Site* on behalf of our client, Cyprus-Foote Mineral Company. This report has been prepared consistent with the requirements of Paragraph VIII.E of the Administrative Order on Consent (USEPA Docket No. III-94-23-DE).

Please review the information provided in this report and if you have any questions or require additional information, please call Pat Lee at Cyprus Foote Mineral at (303) 643-5652, me at (610) 524-3610 or Mike Eversman at (610) 524-3903.

Sincerely,
(b) (4)

ERM Project Manager

ME/

cc: (b) (4)
A. Flipse, PADEP



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TABLE OF CONTENTS

PFE ORIGINAL

EXECUTIVE SUMMARY	xix
1.0 INTRODUCTION	1-1
1.1 PROJECT OBJECTIVES	1-2
1.2 REPORT FORMAT	1-3
1.3 PROJECT BACKGROUND	1-4
1.4 SITE DESCRIPTION	1-4
1.4.1 Site Location and Description	1-4
1.4.2 Site History	1-6
2.0 SUMMARY OF PRE-RI DATA	2-1
2.1 US EPA SITE INSPECTION	2-1
2.2 PHASE I ENVIRONMENTAL ASSESSMENT	2-2
2.3 PHASE II PRELIMINARY REMEDIAL MEASURES STUDY	2-2
2.4 PHASE III INVESTIGATION	2-3
2.4.1 Phase III-Stage 1 Ground Water Characterization and Remediation	2-3
2.4.2 Phase III-Stage 2 Investigation of the North and South Quarries	2-4
2.4.3 Phase III-Stage 3 Investigation of Potential Soil Contamination Areas	2-4
2.5 REGIONAL GEOLOGY AND HYDROGEOLOGY	2-5
2.5.1 Regional Geology	2-5
2.5.2 Regional Hydrogeology	2-6
2.6 SITE SOILS, GEOLOGY, AND HYDROGEOLOGY	2-8
2.6.1 Site Geology	2-8
2.6.2 Site Hydrogeology	2-9
2.6.2.1 Bedrock Aquifer	2-9
2.7 SUMMARY OF ANALYTICAL DATA	2-10
2.7.1 North and South Quarries	2-11
2.7.1.1 Inorganics - North Quarry	2-11
2.7.1.2 Inorganics - South Quarry	2-12

TABLE OF CONTENTS

2.7.1.3	Volatile Organic Compounds	2-13
2.7.1.4	Inorganics - EP Toxicity Results	2-13
2.7.2	Former Lithium Drum Cleaning Area	2-14
2.7.3	Main Plant Area	2-14
2.7.3.1	Former Septic System Area	2-14
2.7.3.2	Chromite Ore Storage Areas	2-15
2.7.3.3	Former Wash Pond Area	2-16
2.7.3.4	Arsenite Disposal Area	2-16
2.7.3.5	Former Solvent Burn Area	2-17
2.7.3.6	Former Settling Pond Area	2-18
2.7.3.7	Former Colemanite (Boron Ore) Storage Area	2-19
2.7.3.8	Background Soils West of Plant	2-20
2.7.4	Ground Water	2-21
2.7.4.1	North and South Quarry Monitoring Wells	2-22
2.7.4.2	Site-Wide Bedrock Monitoring Wells	2-23
2.7.4.3	Former Solvent Burn Area	2-25
2.7.4.4	Off-Site Wells	2-26
2.7.5	Surface Water and Sediment	2-28
2.7.5.1	On-Site Surface Water and Sediment	2-28
2.7.5.2	Off-Site Surface Water	2-29
3.0	RI WORK PLAN INVESTIGATION ELEMENTS	3-1
3.1	TASK 1 - PRELIMINARY SITE CHARACTERIZATION	3-1
3.1.1	Subtask 1.1 Site Survey and Mapping	3-1
3.1.2	Subtask 1.2 Fracture Trace Analysis	3-2
3.2	TASK 2 - SOIL INVESTIGATION	3-3
3.2.1	Subtask 2.1 Soil Sampling Activities	3-3
3.2.2	Subtask 2.2 Sampling in Main Plant Area	3-6
3.2.2.1	Transformers	3-6
3.2.3	Subtask 2.3 Geotechnical Analysis	3-6
3.3	TASK 3 - GROUND WATER INVESTIGATION	3-7
3.3.1	Subtask 3.1 Monitoring Well Assessment	3-8
3.3.2	Subtask 3.2 Water Elevation Survey	3-8
3.3.3	Subtask 3.3 Borehole Logging of Selected Monitoring Wells	3-9
3.3.4	Subtask 3.4 Downhole Camera Survey	3-10
3.3.5	Subtask 3.5 Packer Testing	3-10
3.3.6	Subtask 3.6 Monitoring Well Installation	3-11
3.3.7	Subtask 3.7 Ground Water Sampling	3-14

TABLE OF CONTENTS

3.4	TASK 4 - SURFACE WATER/SEDIMENT SAMPLING	3-15
3.4.1	<i>Equalization Basin</i>	3-16
3.4.2	<i>Concrete Pit Sump (South Quarry)</i>	3-17
3.4.3	<i>Drainage Areas on Western Portion of Plant</i>	3-17
3.5	TASK 6 - DATA REPORTING, VALIDATION, AND REDUCTION	3-17
3.6	TASK 7 - DATA EVALUATION AND REPORT PREPARATION	3-19
4.0	RI INVESTIGATION RESULTS	4-1
4.1	PRELIMINARY SITE CHARACTERIZATION	4-1
4.1.1	<i>Site Survey and Mapping</i>	4-1
4.1.2	<i>Fracture Trace Analysis</i>	4-1
4.2	SOIL INVESTIGATION	4-2
4.2.1	<i>North Quarry</i>	4-3
4.2.2	<i>South Quarry</i>	4-3
4.2.3	<i>Background Locations</i>	4-4
4.2.4	<i>Chromite Ore Storage Area</i>	4-4
4.2.5	<i>Colemanite Ore Storage Area</i>	4-5
4.2.6	<i>Former Settling Ponds</i>	4-5
4.2.7	<i>Former Solvent Burn Area</i>	4-5
4.2.8	<i>Former Wash Pond</i>	4-6
4.2.9	<i>Main Plant Areas</i>	4-7
4.2.9.1	<i>Building 16 Area</i>	4-7
4.2.9.2	<i>Building 17 Pads Area</i>	4-7
4.2.9.3	<i>Buildings 18/19/19A Tanks and Tank Cradles Area</i>	4-8
4.2.9.4	<i>Tank Adjacent to Building 23 Area</i>	4-8
4.2.9.5	<i>Building 30 Hazardous Storage Area</i>	4-8
4.2.9.6	<i>Building 40 Pile Area</i>	4-9
4.2.9.7	<i>Building 45 Pile Area</i>	4-9
4.2.9.8	<i>Equalization Basin Area</i>	4-9
4.2.10	<i>Transformer Areas</i>	4-10
4.2.10.1	<i>Building 13 Area</i>	4-10
4.2.10.2	<i>Building 20</i>	4-10
4.2.10.3	<i>Building 37</i>	4-10
4.2.10.4	<i>Building 38</i>	4-10
4.2.10.5	<i>Building 52</i>	4-10
4.2.11	<i>Geotechnical Analysis</i>	4-11

4.3	GROUND WATER INVESTIGATION	4-11
4.3.1	<i>Preliminary Tasks</i>	4-11
4.3.2	<i>Borehole Logging of Selected Monitoring Wells</i>	4-11
4.3.3	<i>Downhole Camera Survey</i>	4-15
4.3.4	<i>Packer Testing</i>	4-15
4.3.5	<i>Site Geology</i>	4-17
4.3.6	<i>Site Hydrogeology</i>	4-17
4.3.7	<i>Analytical Results</i>	4-19
4.4	SURFACE WATER AND SEDIMENT INVESTIGATION	4-21
4.4.1	<i>East Valley Creek</i>	4-22
4.4.1.1	<i>Surface Water</i>	4-22
4.4.1.2	<i>Sediment</i>	4-23
4.4.2	<i>West Valley Creek Drainage Area</i>	4-24
4.4.2.1	<i>Surface Water</i>	4-24
4.4.2.2	<i>Sediment</i>	4-25
4.4.3	<i>Plant Sediment</i>	4-25
5.0	HUMAN HEALTH RISK ASSESSMENT	5-1
5.1	INTRODUCTION	5-1
5.1.1	<i>Description of Current Conditions</i>	5-2
5.1.2	<i>Human Health Risk Assessment Methodology</i>	5-2
5.2	HAZARD IDENTIFICATION	5-3
5.2.1	<i>Data Sources</i>	5-3
5.2.2	<i>Selection of Contaminants of Concern</i>	5-4
5.2.3	<i>Summary of Contaminants of Potential Concern</i>	5-5
5.3	EXPOSURE ASSESSMENT	5-11
5.3.1	<i>Characterization of Exposure Setting</i>	5-12
5.3.1.1	<i>On-Site Worker Exposure</i>	5-13
5.3.1.2	<i>Future Hypothetical Residential Exposure</i>	5-13
5.3.1.3	<i>Trespasser Exposure</i>	5-14
5.3.2	<i>Identification of Exposure Pathways</i>	5-14
5.3.2.1	<i>Media and Exposure Routes of Concern</i>	5-14
5.3.2.2	<i>Summary of Exposure Pathways Considered</i>	5-15
5.3.2.3	<i>Exposure Scenarios</i>	5-15
5.3.2.4	<i>Quantification of Exposure</i>	5-17
5.3.2.5	<i>Estimation of Exposure Doses</i>	5-19

5.4	TOXICITY ASSESSMENT	5-19
5.4.1	<i>Alternative Toxicity Assessment for Select COPCs</i>	5-21
5.5	RISK CHARACTERIZATION	5-26
5.5.1	<i>Carcinogenic Risk</i>	5-27
5.5.2	<i>Noncarcinogenic Effects</i>	5-39
5.6	UNCERTAINTY	5-48
5.6.1	<i>General Methodological Uncertainties</i>	5-48
5.6.1.1	<i>Site Characterization</i>	5-48
5.6.1.2	<i>Toxicological Information</i>	5-49
5.6.1.3	<i>Exposure Assumptions</i>	5-50
5.6.1.4	<i>Risk Characterization</i>	5-52
5.7	SUMMARY OF HHRA	5-52
6.0	ECOLOGICAL RISK ASSESSMENT	6-1
6.1	INTRODUCTION	6-1
6.1.1	<i>General Site Description and RI Data Collection</i>	6-2
6.1.2	<i>ERA Methodology</i>	6-2
6.2	PROBLEM FORMULATION	6-3
6.2.1	<i>Objectives</i>	6-3
6.2.2	<i>Fate and Transport Processes</i>	6-3
6.2.3	<i>Preliminary Exposure Pathways, Routes and Receptors of Concern</i>	6-7
6.2.4	<i>Assessment Endpoint</i>	6-7
6.2.4	<i>Measurement Endpoint</i>	6-8
6.2.5	<i>Conceptual Model</i>	6-8
6.3	EXPOSURE ASSESSMENT	6-9
6.3.1	<i>Ecological Habitat Characterization</i>	6-9
6.3.1.1	<i>Regional Ecology</i>	6-9
6.3.1.2	<i>Site Ecology</i>	6-10
6.3.2	<i>Identification of Ecological Receptors</i>	6-15
6.3.2.1	<i>Threatened and Endangered Species</i>	6-16
6.3.3	<i>Identification of Potential Exposure Pathways</i>	6-17
6.3.3.1	<i>Soil</i>	6-18
6.3.3.2	<i>Sediment</i>	6-19
6.3.3.3	<i>Surface Water</i>	6-22
6.3.3.4	<i>Ground Water</i>	6-23

TABLE OF CONTENTS

6.4	ECOLOGICAL EFFECTS ASSESSMENT	6-23
6.4.1	<i>Effects Assessment Methodology</i>	6-23
6.4.2	<i>Results</i>	6-25
6.5	RISK CHARACTERIZATION	6-27
6.5.1	<i>Discussion of Soil Screening Results</i>	6-27
6.5.1.1	<i>Ruderal and Former Industrial Area</i>	6-27
6.5.1.2	<i>Early Seral Annuals and Perennials Area</i>	6-28
6.5.1.3	<i>North Quarry and South Quarry Areas</i>	6-29
6.5.2	<i>Discussion of Truly Aquatic Sediment Screening Results</i>	6-30
6.5.2.1	<i>Inlet and Outlet Pipes to the Equalization Basin</i>	6-30
6.5.2.2	<i>West Valley Creek</i>	6-31
6.5.2.3	<i>East Valley Creek</i>	6-32
6.5.3	<i>Discussion of Semi-Aquatic Sediment Screening Results</i>	6-33
6.5.3.1	<i>Ruderal and Former Industrial Area</i>	6-33
6.5.3.2	<i>Early Seral Annuals and Perennials Area</i>	6-34
6.5.3.3	<i>Drainage Ditch to West Valley Creek</i>	6-35
6.5.4	<i>Discussion of Surface Water Screening Results</i>	6-36
6.5.4.1	<i>Inlet Pipe to the Equalization Pond</i>	6-36
6.5.4.2	<i>Ponded Area</i>	6-37
6.5.4.3	<i>West Valley Creek</i>	6-37
6.5.4.4	<i>East Valley Creek</i>	6-38
6.5.5	<i>Uncertainty Analysis</i>	6-40
6.6	CONCLUSIONS	6-42
6.7	REFERENCES	6-44
7.0	CONCLUSIONS	7-1
7.1	INVESTIGATION CONCLUSIONS	7-1
7.1.1	<i>Groundwater</i>	7-1
7.1.2	<i>Soils</i>	7-3
7.1.3	<i>Surface Water and Sediment</i>	7-3
7.2	RISK ASSESSMENT CONCLUSIONS	7-4
7.2.1	<i>Human Health Risk Assessment</i>	7-4
7.2.2	<i>Ecological Risk Assessment</i>	7-4
7.3	RECOMMENDATIONS	7-5

APPENDICES

PFE ORIGINAL

- A SOIL BORING LOGS**
- B ERM QUALITY ASSURANCE REPORTS**
- C GEOPHYSICAL LOGS**
- D PACKER TEST FIELD INFORMATION SUMMARIES**
- E WELL LOGS**
- F VIDEO LOG SUMMARIES**
- G PACKER TESTING ANALYTICAL RESULTS**
- H TOXICITY PROFILES**

LIST OF FIGURES

PFE ORIGINAL

1-1	<i>Site Location Map</i>
1-2	<i>Site Map</i>
2-1	<i>Regional Geologic Map</i>
2-2	<i>Regional Water Table Contour Map Showing Geological Contacts</i>
2-3	<i>Well Location Map</i>
2-4	<i>Bedrock Ground Water Elevation Contour Map (3 December 1990)</i>
2-5	<i>North Quarry Sample Locations</i>
2-6	<i>South Quarry Sample Locations</i>
2-7	<i>Phase III Stage 3 Sampling Locations</i>
2-8	<i>Phase I Sampling Locations</i>
2-9	<i>Selected Off-Site Well Locations</i>
2-10	<i>Surface Water/Sediment Sample Locations</i>
3-1	<i>Site Topography Map</i>
3-2	<i>Monitoring Well Location Map</i>
3-3	<i>Well Construction Schematic Nested Bedrock Monitoring Wells</i>
3-4	<i>Surface Water/Sediment Sampling Location Map</i>
3-5	<i>Surface Water/Sediment Sampling Locations</i>
4-1	<i>Fracture Trace Analysis</i>
4-2	<i>Cross Section Location Map</i>
4-3	<i>Cross Section A-A'</i>
4-4	<i>Cross Section B-B'</i>
4-5	<i>Cross Section C-C'</i>
4-6	<i>Bedrock Ground Water Elevation Map - 4 April 1997</i>
4-7	<i>Bedrock Ground Water Elevation Map - 16 May 1997</i>
4-8	<i>Bedrock Ground Water Elevation Map - 27 June 1997</i>
4-9	<i>Bedrock Ground Water Elevation Map - 30 July 1997</i>
4-10	<i>Bedrock Ground Water Elevation Map - 21 August 1997</i>
4-11	<i>Bedrock Ground Water Elevation Map - 25 September 1997</i>
4-12	<i>Bedrock Ground Water Elevation Map - 21 October 1997</i>
6-1	<i>Generalized Sitewide Conceptual Model for Potential Ecological Exposures - Remedial Investigation/Risk Assessment</i>
6-2	<i>Habitat Covertypes Map</i>

LIST OF TABLES

1-1	<i>Guidance Documents for RI/FS</i>
2-1	<i>Areas of Concern Where Constituent Concentrations Exceed US EPA RBCs in One or More Pre-RI Samples</i>
2-2a	<i>Average Inorganic and Organic Concentrations in Shallow Fill, North Quarry</i>
2-2b	<i>Average Inorganic Concentrations in Subsurface Fill, North Quarry</i>
2-3a	<i>Average Inorganic and Organic Concentrations in Shallow Fill, South Quarry</i>
2-3b	<i>Average Inorganic Concentrations in Subsurface Fill, South Quarry</i>
2-4	<i>Quarry Fill EP Toxicity Results, North and South Quarries</i>
2-5	<i>Average Inorganic and Organic Concentrations in Soils, Former Septic System Area</i>
2-6	<i>Inorganic Concentrations in Shallow and Subsurface Soils, Chromite Ore Storage Area</i>
2-7	<i>Average Inorganic Concentrations, Former Wash Pond Area</i>
2-8	<i>Average Inorganic Concentrations, Arsenite Disposal Area</i>
2-9	<i>Average Inorganic and Organic Concentrations, Former Solvent Burn Area</i>
2-10a	<i>Average Inorganic and Organic Concentrations in Shallow Soils, Former Settling Ponds Area</i>
2-10b	<i>Average Inorganic and Organic Concentrations in Subsurface Soils, Former Settling Ponds Area</i>
2-11	<i>TCLP Analytical Results from Composite Soil Samples, Former Settling Pond Area</i>
2-12	<i>Inorganic Concentrations in Background Shallow Soils</i>
2-13	<i>Phase II and Phase III Inorganic Data, North and South Quarry Monitoring Wells</i>
2-14	<i>Phase III Volatile Organics Data, Site-Wide Bedrock Monitoring Wells</i>
2-15	<i>Phase III Data - Selected Inorganics, Site-Wide Bedrock Monitoring Wells</i>
2-16	<i>Dissolved Boron and Lithium Concentrations in the Valley Creek</i>
3-1	<i>Summary of Soil Sampling</i>
3-2	<i>Monitoring Well Construction Summary</i>
3-3	<i>Limited Analyte List for Water Sampling</i>
3-4	<i>Extended Analyte List for Water Sampling</i>
3-5	<i>Summary of Surface Water and Sediment Sampling Program</i>
4-1	<i>Ground Water Elevations</i>
4-2	<i>Summary of Measured Field Parameters, April 1997 Ground Water Sampling Event</i>
4-3	<i>Summary of Measured Field Parameters, November 1996 Surface Water Sampling Event</i>
4-4	<i>Analytical Results</i>

LIST OF TABLES

PFE ORIGINAL

5-0	<i>Summary of Retained COPCs</i>
5-1	<i>Results of Screening Analysis - North Quarry Confirmation Area (NQC)</i>
5-2	<i>Results of Screening Analysis - South Quarry Confirmation Area (SQC)</i>
5-3	<i>Results of Screening Analysis - Former Settling Ponds (FSP)</i>
5-4	<i>Results of Screening Analysis - Former Wash Ponds Area (FWPA)</i>
5-5	<i>Results of Screening Analysis - Former Solvent Burn Area (SBA)</i>
5-6	<i>Results of Screening Analysis - Chromite Ore Storage Area (CRSA)</i>
5-7	<i>Results of Screening Analysis - Colmanite Ore Storage Area (COSA)</i>
5-8	<i>Results of Screening Analysis - Building 16 (Runoff and Discharge Area)</i>
5-9	<i>Results of Screening Analysis - Building 17 Pads, Storage Area</i>
5-10	<i>Results of Screening Analysis - Building 18/19/19A Tanks and Tank Cradles</i>
5-11	<i>Results of Screening Analysis - Tanks Adjacent to Building 23</i>
5-12	<i>Results of Screening Analysis - Building 30 Hazardous Storage</i>
5-13	<i>Results of Screening Analysis - Building 40 Pile</i>
5-14	<i>Results of Screening Analysis - Building 45 Pile</i>
5-15	<i>Results of Screening Analysis - Piles Near Equalization Pond (EQP)</i>
5-16	<i>Results of Screening Analysis - Building 13 Transformers</i>
5-17	<i>Results of Screening Analysis - Building 20 Transformers</i>
5-18	<i>Results of Screening Analysis - Building 37 Transformers</i>
5-19	<i>Results of Screening Analysis - Building 38 Transformers</i>
5-20	<i>Results of Screening Analysis - Building 52 Transformers</i>
5-21	<i>Results of Screening Analysis - Groundwater</i>
5-22	<i>Results of Screening Analysis - Surface Water</i>
5-23	<i>Results of Screening Analysis - Sediment</i>
5-24	<i>Soil Ingestion Intake Factor Assumptions</i>
5-25	<i>Soil Dermal Contact Intake Factor Assumptions</i>
5-26	<i>Soil Inhalation Intake Factor Assumptions - Particulates</i>
5-27	<i>Soil Ingestion Intake Factor Assumptions</i>
5-28	<i>Soil Dermal Contact Intake Factor Assumptions</i>
5-29	<i>Soil Inhalation Intake Factor Assumptions - Particulates</i>
5-30	<i>Ground Water Ingestion Intake Factor Assumptions (Drinking Water)</i> <i>Hypothetical Future On-Site Child and Adult Residents</i>
5-31	<i>Ground Water Dermal Contact Intake Factor Assumptions (Showering)</i> <i>Hypothetical Future On-Site Child and Adult Resident</i>
5-32	<i>Ground Water Dermal Contact Intake Factor Assumptions (Showering)</i> <i>Future On-Site Child and Adult Resident</i>
5-33	<i>Ground Water Inhalation Intake Factor Assumptions</i> <i>Hypothetical Future On-Site Child and Adult Residents</i>
5-34	<i>Surface Water Ingestion Intake Factor Assumption</i> <i>Hypothetical Future On-Site Child and Adult Residents</i>
5-35	<i>Surface Water Dermal Contact Intake Factor Assumptions (Wading)</i>

5-36	<i>Surface Water Dermal Contact Intake Factor Calculations</i>
5-37	<i>Surface Water Inhalation Intake Factor Assumptions</i>
	<i>Hypothetical Future On-Site Child and Adult Resident</i>
5-38	<i>Sediment Ingestion Intake Factor Assumptions (Wading)</i>
	<i>Hypothetical Future On-Site Child and Adult Residents</i>
5-39	<i>Sediment Dermal Contact Intake Factor Assumptions (Wading)</i>
	<i>Hypothetical Future On-Site Child and Adult Residents</i>
5-40	<i>Sediment Inhalation Intake Factor Assumptions (Particulates)(Wading)</i>
	<i>Hypothetical Future On-Site Child and Adult Residents</i>
5-41	<i>Soil Ingestion Intake Factor Assumptions</i>
5-42	<i>Soil Dermal Contact Intake Factor Assumptions</i>
5-43	<i>Soil Inhalation Intake Factor Assumptions - Particulates</i>
5-44	<i>Reasonable Maximum Exposure Concentrations in Soil</i>
5-45	<i>Reasonable Maximum Exposure Concentrations in Soil</i>
5-46	<i>Reasonable Maximum Exposure Concentrations in Soil - Transformer Area</i>
5-47	<i>Summary of Reasonable Maximum Exposure Concentrations in Ground Water</i>
5-48	<i>Reasonable Maximum Exposure Concentrations in Surface Water</i>
5-49	<i>Reasonable Maximum Exposure Concentrations in Sediment</i>
5-50a	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - North Quarry Confirmation Area (NQC)</i>
	<i>Future On-Site Adult Worker</i>
5-50b	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - North Quarry Confirmation Area (NQC)</i>
	<i>Future On-Site Adult Resident</i>
5-50c	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - North Quarry Confirmation Area (NQC)</i>
	<i>Future On-Site Child Resident</i>
5-50d	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - North Quarry Confirmation Area (NQC)</i>
	<i>On-Site Child Trespasser (9-18 years old)</i>
5-51a	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - South Quarry Confirmation Area (SQC)</i>
	<i>Future On-Site Adult Worker</i>
5-51b	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - South Quarry Confirmation Area (SQC)</i>
	<i>Future On-Site Adult Resident</i>
5-51c	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - South Quarry Confirmation Area (SQC)</i>
	<i>Future On-Site Child Resident</i>

LIST OF TABLES

PFE ORIGINAL

5-51d	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - South Quarry Confirmation Area (SQC) On-Site Child Trespasser (9-18 years old)</i>
5-52a	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Former Settling Ponds (FSP) Future On-Site Adult Worker</i>
5-52b	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Former Settling Ponds (FSP) Future On-Site Adult Resident</i>
5-52c	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Former Settling Ponds (FSP) Future On-Site Child Resident</i>
5-52d	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Former Settling Ponds (FSP) On-Site Child Trespasser (9-18 years old)</i>
5-53a	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Former Wash Ponds Area (FWPA) Future On-Site Adult Worker</i>
5-53b	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Former Wash Ponds Area (FWPA) Future On-Site Adult Resident</i>
5-53c	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Former Wash Ponds Area (FWPA) Future On-Site Child Resident</i>
5-53d	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Former Wash Ponds Area (FWPA) On-Site Child Trespasser (9-18 years old)</i>
5-54a	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Solvent Burn Area (SBA) Future On-Site Adult Worker</i>
5-54b	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Solvent Burn Area (SBA) Future On-Site Adult Resident</i>
5-54c	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Solvent Burn Area (SBA) Future On-Site Child Resident</i>
5-54d	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Solvent Burn Area (SBA) On-Site Child Trespasser (9-18 years old)</i>
5-55a	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Chromite Storage Area (CRSA) Future On-Site Adult Worker</i>

LIST OF TABLES

PFE ORIGINAL

5-55b	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Chromite Storage Area (CRSA) Future On-Site Adult Resident</i>
5-55c	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Chromite Storage Area (CRSA) Future On-Site Child Resident</i>
5-55d	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Chromite Storage Area (CRSA) On-Site Child Trespasser (9-18 years old)</i>
5-56a	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Colmanite Storage Area (COSA) Future On-Site Adult Worker</i>
5-56b	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Colmanite Storage Area (COSA) Future On-Site Adult Resident</i>
5-56c	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Colmanite Storage Area (COSA) Future On-Site Child Resident</i>
5-56d	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Colmanite Storage Area (COSA) On-Site Child Trespasser (9-18 years old)</i>
5-57a	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Building 16 Future On-Site Adult Worker</i>
5-57b	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Building 16 Future On-Site Adult Resident</i>
5-57c	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Building 16 Future On-Site Child Resident</i>
5-57d	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Building 16 On-Site Child Trespasser (9-18 years old)</i>
5-58a	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Building 17 Pads, Storage Area Future On-Site Adult Worker</i>
5-58b	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Building 17 Pads, Storage Area Future On-Site Adult Resident</i>
5-58c	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Building 17 Pads, Storage Area Future On-Site Child Resident</i>

LIST OF TABLES

PFE ORIGINAL

5-58d	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Building 17 Pads, Storage Area On-Site Child Trespasser (9-18 years old)</i>
5-59a	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Building 18/19/19A Future On-Site Adult Worker</i>
5-59b	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Building 18/19/19A Future On-Site Adult Resident</i>
5-59c	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Building 18/19/19A Future On-Site Child Resident</i>
5-59d	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Building 18/19/19A On-Site Child Trespasser (9-18 years old)</i>
5-60a	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Tanks Adjacent to Building 23 Future On-Site Adult Worker</i>
5-60b	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Tanks Adjacent to Building 23 Future On-Site Adult Resident</i>
5-60c	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Tanks Adjacent to Building 23 Future On-Site Child Resident</i>
5-60d	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Tanks Adjacent to Building 23 On-Site Child Trespasser (9-18 years old)</i>
5-61a	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Building 30 Future On-Site Adult Worker</i>
5-61b	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Building 30 Future On-Site Adult Resident</i>
5-61c	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Building 30 Future On-Site Child Resident</i>
5-61d	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Building 30 On-Site Child Trespasser (9-18 years old)</i>
5-62a	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Building 40 Pile Future On-Site Adult Worker</i>

5-62b	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Building 40 Pile Future On-Site Adult Resident</i>
5-62c	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Building 40 Pile Future On-Site Child Resident</i>
5-62d	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Building 40 Pile On-Site Child Trespasser (9-18 years old)</i>
5-63a	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Building 45 Pile Future On-Site Adult Worker</i>
5-63b	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Building 45 Pile Future On-Site Adult Resident</i>
5-63c	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Building 45 Pile Future On-Site Child Resident</i>
5-63d	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Building 45 Pile On-Site Child Trespasser (9-18 years old)</i>
5-64a	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Piles Near Equalization Pond Area (EQP) Future On-Site Adult Worker</i>
5-64b	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Piles Near Equalization Pond Area (EQP) Future On-Site Adult Resident</i>
5-64c	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Piles Near Equalization Pond Area (EQP) Future On-Site Child Resident</i>
5-64d	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Piles Near Equalization Pond Area (EQP) On-Site Child Trespasser (9-18 years old)</i>
5-65a	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Building 13 Transformers Future On-Site Adult Worker</i>
5-65b	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Building 13 Transformers Future On-Site Adult Resident</i>
5-65c	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Building 13 Transformers Future On-Site Child Resident</i>

LIST OF TABLES

PFE ORIGINAL

5-65d	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Building 13 Transformers On-Site Child Trespasser (9-18 years old)</i>
5-66a	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Building 20 Transformers Future On-Site Adult Worker</i>
5-66b	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Building 20 Transformers Future On-Site Adult Resident</i>
5-66c	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Building 20 Transformers Future On-Site Child Resident</i>
5-66d	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Building 20 Transformers On-Site Child Trespasser (9-18 years old)</i>
5-67a	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Building 38 Transformers Future On-Site Adult Worker</i>
5-67b	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Building 38 Transformers Future On-Site Adult Resident</i>
5-67c	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Building 38 Transformers Future On-Site Child Resident</i>
5-67d	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Soil - Building 38 Transformers On-Site Child Trespasser (9-18 years old)</i>
5-68	<i>Total Noncarcinogenic and Carcinogenic Risks from Potential Exposures to Ground Water Hypothetical Future On-Site Child Resident Hypothetical Future On-Site Adult Resident</i>
5-69	<i>Total Noncarcinogenic and Carcinogenic Risks from Potential Exposures to Surface Water Hypothetical Future On-Site Child Resident Hypothetical Future On-Site Adult Resident</i>
5-70	<i>Total Noncarcinogenic and Carcinogenic Risks for Potential Exposure to Sediment Hypothetical Future On-Site Child and Adult Resident</i>
5-71	<i>Total Noncarcinogenic and Carcinogenic Risks from Potential Exposures to Ground Water at (b) Well Hypothetical Future On-Site Child Resident Hypothetical Future On-Site Adult Resident</i>

6-1	<i>List of Observed Vegetation within Major Habitat Covertypes</i>
6-2	<i>List of Observed and Expected Ecological Receptors</i>
6-3	<i>Preliminary List of COPCs in Soil from the Ruderal and Former Industrial Area</i>
6-4	<i>Preliminary List of COPCs in Soil from the Early Seral Annuals and Perennials Area</i>
6-5	<i>Preliminary List of COPCs in Soil from the Quarry Areas</i>
6-6	<i>Results of Soil Screening Analysis - Building 13 Transformer in the Ruderal and Former Industrial Area</i>
6-7	<i>Results of Soil Screening Analysis - Building 16 in the Ruderal and Former Industrial Area</i>
6-8	<i>Results of Soil Screening Analysis - Building 17 in the Ruderal and Former Industrial Area</i>
6-9	<i>Results of Soil Screening Analysis - Building 18/19/19A in the Ruderal and Former Industrial Area</i>
6-10	<i>Results of Soil Screening Analysis - Building 20 Transformer in the Ruderal and Former Industrial Area</i>
6-11	<i>Results of Soil Screening Analysis - Building 23 in the Ruderal and Former Industrial Area</i>
6-12	<i>Results of Soil Screening Analysis - Building 30 in the Ruderal and Former Industrial Area</i>
6-13	<i>Results of Soil Screening Analysis - Building 37 Transformer in the Ruderal and Former Industrial Area</i>
6-14	<i>Results of Soil Screening Analysis - Building 38 Transformer in the Ruderal and Former Industrial Area</i>
6-15	<i>Results of Soil Screening Analysis - Building 40 Pile in the Ruderal and Former Industrial Area</i>
6-16	<i>Results of Soil Screening Analysis - Building 45 Pile in the Ruderal and Former Industrial Area</i>
6-17	<i>Results of Soil Screening Analysis - Building 52 Transformer in the Ruderal and Former Industrial Area</i>
6-18	<i>Results of Soil Screening Analysis - Former Wash Ponds Area (FWPA) in the Ruderal and Former Industrial Area</i>
6-19	<i>Overall Summary of Soil and Screening Results for the Ruderal and Former Industrial Area</i>
6-20	<i>Results of Soil Screening Analysis - Chromite Ore Storage Area (CRSA) in the Early Seral Annuals and Perennials Area</i>
6-21	<i>Results of Soil Screening Analysis - Colmanite Ore Storage Area (COSA) in the Early Seral Annuals and Perennials Area</i>
6-22	<i>Results of Soil Screening Analysis - Former Settling Ponds (FSP) in the Early Seral Annuals and Perennials Area</i>

LIST OF TABLES

- 6-23 *Results of Soil Screening Analysis - Former Solvent Burn Area (SBA) in the Early Seral Annuals and Perennials Area*
- 6-24 *Results of Soil Screening Analysis - Piles Near Equalization Pond (EQP) in the Early Seral Annuals and Perennials Area*
- 6-25 *Overall Summary of the Soil Screening Results for the Early Seral Annuals and Perennials Area*
- 6-26 *Results of Soil Screening Analysis - North Quarry Confirmation Area (NQC)*
- 6-27 *Results of Soil Screening Analysis - South Quarry Confirmation Area (SQC)*
- 6-28 *Preliminary List of COPCs in Downgradient Sediment East Valley Creek and West Valley Creek and Sediment in Equalization Basin Inlet and Outlet Pipes*
- 6-29 *Results of Ecological Screening Analysis - Inlet Pipe Sediment*
- 6-30 *Results of Ecological Screening Analysis - Outlet Pipe Sediment*
- 6-31 *Results of Ecological Screening Analysis - West Valley Creek*
- 6-32 *Results of Sediment Screening Analysis - East Valley Creek*
- 6-33 *Preliminary COPCs in Sediment*
- 6-34 *Results of Screening Analysis - Ruderal and Former Industrial Area (Sediment/Soil)*
- 6-35 *Results of Sediment Screening Analysis - Early Seral Annuals and Perennials*
- 6-36 *Summary of Soil Screening Results for the Reference Location*
- 6-37 *Results of Sediment Screening Analysis - Drainage Ditch*
- 6-38 *Preliminary List of COPCs in Surface Water*
- 6-39 *Results of Ecological Screening Analysis - Equalization Basin Inlet Pipe Surface Water*
- 6-40 *Results of Surface Water Screening Analysis - Ponded Area*
- 6-41 *Results of Surface Water Screening Analysis - West Valley Creek*
- 6-42 *Results of Surface Water Screening Analysis - East Valley Creek*

Executive Summary

Section 1

Executive Summary

1.0

INTRODUCTION

Environmental Resources Management (ERM) has completed investigation activities for the Remedial Investigation (RI) and Risk Assessment (RA) at the former Cyprus Foote Mineral Company Site located on Bacton Hill Road, East Whiteland Township, Pennsylvania, herein referred to as the Site (Figure 1-1). This work was completed pursuant to the Administrative Order on Consent EPA Docket No. III-94-23-DC effective 9/27/96 for the Site. Based on the findings of the RI/RA, ERM has prepared this RI/RA Report for our client, Cyprus Foote Mineral (CFM).

The purpose of this RI is to summarize the scope of work completed as required by the United States Environmental Protection Agency (US EPA)-approved Remedial Investigation/Feasibility Study (RI/FS) Work Plan (ERM, 1995) and to assimilate pre-RI site-specific data necessary to characterize the physical and chemical conditions at the Site.

Between 1988 and 1992, CFM completed a series of pre-RI investigations. ERM reviewed and summarized the existing pre-RI investigative reports and has incorporated the significant findings and discussion from these reports into the RI. A summary discussion of the results from the pre-RI investigations is included in Section 2. The results of the data review were used to focus additional sample collection efforts. The data collected during the RI focused on the following areas of concern:

- (1) North and South Quarries;
- (2) former Lithium Drum Cleaning Area;
- (3) three former Chromite Ore Storage Areas;
- (4) farmed area west of the plant;
- (5) former Solvent Burn Area;
- (6) former Settling Pond Area;
- (7) former Colemanite (boron ore) Storage Area;
- (8) 9 Main Plant Area soils areas; and
- (9) 5 Main Plant Area transformer locations.

The database generated during the RI was used by ERM to complete an RA and will be used to support the development of a Feasibility Study

(FS). The FS will evaluate applicable remedial technologies and will develop remedial alternatives for the Site.

The sampling program completed during the RI and discussed herein addressed the following media:

- (1) surficial soils in each of the investigation areas;
- (2) subsurface soil;
- (3) ground water;
- (4) stream surface water and sediment; and
- (5) sediments from North and South Quarries.

Investigation activities conducted for this RI were performed using methods which were consistent with the CERCLA guidance including *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (US EPA, October 1988). Additional pertinent guidance documents which were followed are listed in Table 1-1.

1.1

PROJECT OBJECTIVES

At the start of the RI, considerable data existed for the Site from the pre-RI investigative activities. The general objective of the pre-RI investigations was to begin developing a database upon which remedial alternatives could be selected for the Site.

The field investigation activities conducted as part of the pre-RI investigations included the following tasks:

- (1) sampling and analysis of soil and fill collected from the North and South Quarries;
- (2) sampling and analysis of soil samples collected from potential areas of concern which were determined based upon former operations at the plant;
- (3) installation and sampling of ground water monitoring wells to characterize Site hydrogeology and ground water quality;
- (4) performance of a pumping test to quantitatively measure aquifer characteristics;
- (5) sampling and analysis of water samples collected from residential wells located proximal to the facility; and

- (6) collection of surface water samples to evaluate potential Site impacts to ground water near the Site.

The soil and ground water data collected provided an understanding of the relationship between the soil quality and the operations conducted at the Site and sufficiently characterized the ground water to understand the general hydrogeological conditions.

Following these pre-RI activities, the Site was placed on the National Priorities List (NPL). As stated in the RI/FS Work Plan, in order to develop a database which includes the appropriate data for use in selecting and evaluating remedial alternatives for the Site in the context of the CERCLA program, the specific objectives of this RI were to:

- (1) collect current analytical information on the ground water to understand existing conditions;
- (2) collect information on those aspects of the Site where additional data are needed for adequate assessment;
- (3) collect off-site ground water and surface water data to evaluate regional flow conditions and potential impacts; and
- (4) gather sufficient information to develop and evaluate remedial alternatives which are appropriate for achieving protection of human health and the environment.

1.2

REPORT FORMAT

The remaining sections of this RI Report are organized into the following seven sections:

- Section 2 - Summary of Existing Data: presents an overview of the Site with respect to pre-RI analytical data compiled from previous investigations, including a summary of regional and Site geology and hydrogeology;
- Section 3 - RI Work Plan Investigation Elements: describes the methods used during the RI investigation;
- Section 4 - RI Investigation Results: provides a summary of the data obtained during the RI;
- Section 5 - Human Health Risk Assessment: identifies human exposures, pathways, and calculates human risks;

- Section 6 - Ecological Risk Assessment: identifies ecological exposures, pathways, and calculates ecological risks; and
- Section 7 - Summary and Conclusions.

1.3

PROJECT BACKGROUND

Based on elevated concentrations of certain site-specific contaminants in off-site wells, in samples collected by US EPA in 1987, the US EPA and CFM entered into an Administrative Order on Consent pursuant to the Safe Drinking Water Act (SDWA/ Administrative Order on Consent) in June 1990 addressing the investigation of off-site ground water. This investigation included a survey of local wells and analysis of ground water samples collected from nearby commercial and residential wells. Since Maximum Contaminant Levels (MCLs) were not established for lithium or boron, the US EPA established provisional health advisory levels for the purpose of the SDWA/ Administrative Order on Consent for these constituents. The results of the analyses indicated that lithium and boron exceeded the provisional health advisory levels of 900 µg/L and 620 µg/L, respectively at several locations.

The CFM Site was included on the NPL by US EPA in October 1992. Since significant data existed for the Site, CFM proposed to US EPA in a February 1994 meeting to assemble this data. In November 1994, CFM submitted a Preliminary RI (PRI) Report and a supplemental Work Plan addressing any data gaps identified during completion of the PRI and proposing work for the completion of the FS and Risk Assessment. EPA indicated that this approach was acceptable provided that CFM entered into an administrative order to complete the RI/FS.

In 1996, CFM and US EPA entered into an Administrative Order on Consent for completion of the RI/FS and a Risk Assessment at the former CFM plant. The RI field work was initiated in October 1996 and largely completed by July 1997.

1.4

SITE DESCRIPTION

1.4.1

Site Location and Description

The CFM Site, shown on Figure 1-1, occupies 79.3 acres along Swedesford Road in East Whiteland and West Whiteland Townships, Chester County, Pennsylvania. The facility, which closed in August 1991, is bordered on

the north by a single railroad track owned by Conrail and by Swedesford Road; on the west by the Church Farm School property; on the south by PECO Energy property (formerly Philadelphia Electric Company); and on the east by the SRS Leasing and Hill & Perry, Inc. properties. A Conrail rail siding formerly served the plant and is still present on the property. The area surrounding the facility is a combination of agricultural land and suburban residential and commercial developments.

A map of the Site features and discrete areas of concern is provided as Figure 1-2. The eastern portion of the Site is occupied by two quarries (North and South Quarries), operated in the 1930s by the Site's former owner (see Section 1.4.2). The smaller North Quarry is situated approximately 100 feet south of Swedesford Road, and occupies about 1.75 acres. The surface of the North Quarry is approximately 50 feet below grade. This quarry was reportedly used for the disposal of construction rubble, municipal solid waste, and processed mineral fines. In addition, this quarry contains a heterogeneous mixture of soil, mineral fines, and debris. It also received runoff from the lithium drum-cleaning area located immediately southwest of the quarry. The fill was loosely placed to depths ranging between 15 to 20 feet and up to 40 feet deep on the western slope of the quarry. The total volume of the fill is reported to be approximately 67,000 cubic yards.

The South Quarry occupies nearly three acres and the surface is approximately 8 to 26 feet below grade. It is located approximately 40 to 60 feet south of the North Quarry and received lithium ore-processing wastes until 1972. Following this, the South Quarry received process wastewater and storm water run-off until completion of the Equalization Basin around 1977. The South Quarry fill is relatively homogeneous material, composed mostly of slaked lime (calcium hydroxide) and calcium aluminum silicates (lithium ore waste).

This fill was pumped into the South Quarry as a slurry and is present to an observed thickness of up to approximately 60 feet (MW-11). The fill is reported to have a very high moisture content. The total fill volume is reported to be approximately 256,000 cubic yards.

The Main Plant Area is located west of the Quarries and is comprised of more than 50 buildings, and several storage areas which are summarized below:

- Three former chromite (tri-valent chromium ore) storage areas located on concrete pads in the following areas:
 - South of Building 5 near the south property line,

- Southwest of Building 11, and
- Northwest of Building 27 along the northeastern side of the Conrail siding.
- A former Colemanite (boron ore) Storage Area located near the south property line, southwest of the former settling ponds.
- An Equalization Basin, consisting of a 70-foot by 140-foot, lined, wastewater holding pond for the plant's Natural Pollutant Discharge Elimination System (NPDES) effluent, located in the central part of the Site, west of the plant complex. Storm water from the Equalization Basin is discharged to Valley Creek along the western portion of the property through a 1,300-foot long pipeline and ditch.
- A former solvent burn pit located about 250 feet west of the Equalization Basin. This pit was used in the 1960s to burn hexane and other solvents. It was reportedly 10 feet deep and was backfilled with soil upon closure.
- Three former Settling Ponds located south of the Main Plant Area. These unlined ponds were used to settle out slurry from an ore washing process, and occupied approximately one-half acre each.

Since the 1940s, the western portion of the property has been leased to local farmers for agricultural use.

1.4.2

Site History

The Site began industrial operations as a dolomite quarry and processing plant. The quarry and processing plant were operated by Alfred Warner from about 1932 to 1942, when the portion of the property containing the quarries was purchased by Foote Mineral, Inc. From 1942 until 1946 the facility was owned and operated by the Defense Corporation of America. Foote Mineral operated the facility from 1946 to 1988 for the production of lithium chemicals and the processing of a variety of mineral ores, including spodumene, lepidolite, magnetite, chromite, colemanite, manganese and zirconium.

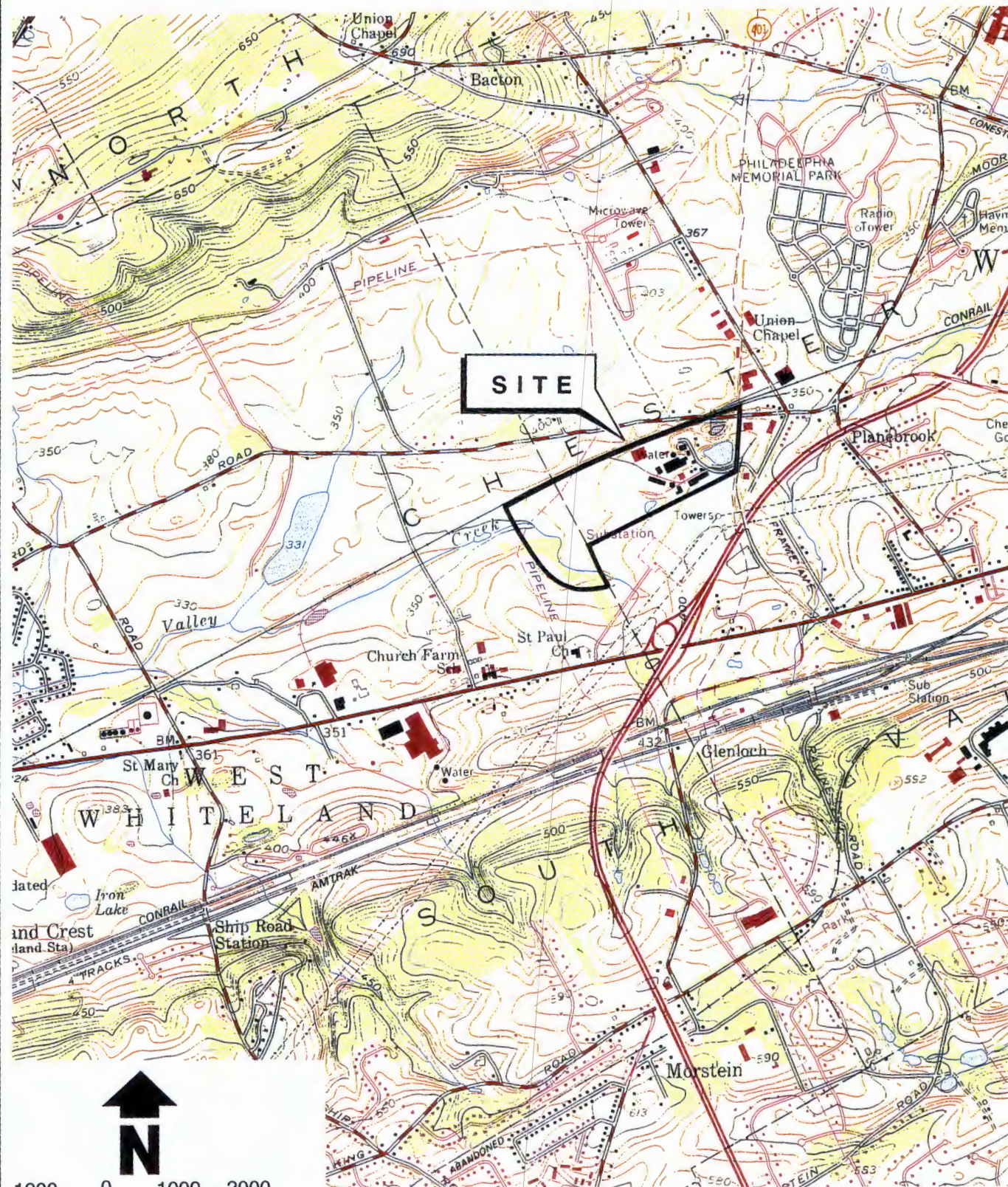
Foote Mineral was purchased in 1988 by Cyprus Minerals Company, and became the Cyprus Foote Mineral Company, a wholly-owned subsidiary of Cyprus Minerals Company. CFM continued operating the facility from 1988 until its closure in August 1991.

From 1942 to 1991, production operations at the Site included the following activities:

- grinding and sizing of various minerals and alloys;
- manufacturing of lithium and strontium chemicals;
- purification of hafnium, zirconium and titanium;
- extraction of lithium from ores;
- manufacturing of lithium metal and zirconium metal powder;
- production of broad lines of non-ferrous master alloys and inorganic fluxes;
- chemical stabilization of metals and alloys;
- manufacturing of manganese sulfide;
- processing of lithium metal produced elsewhere; and
- calcining minerals.

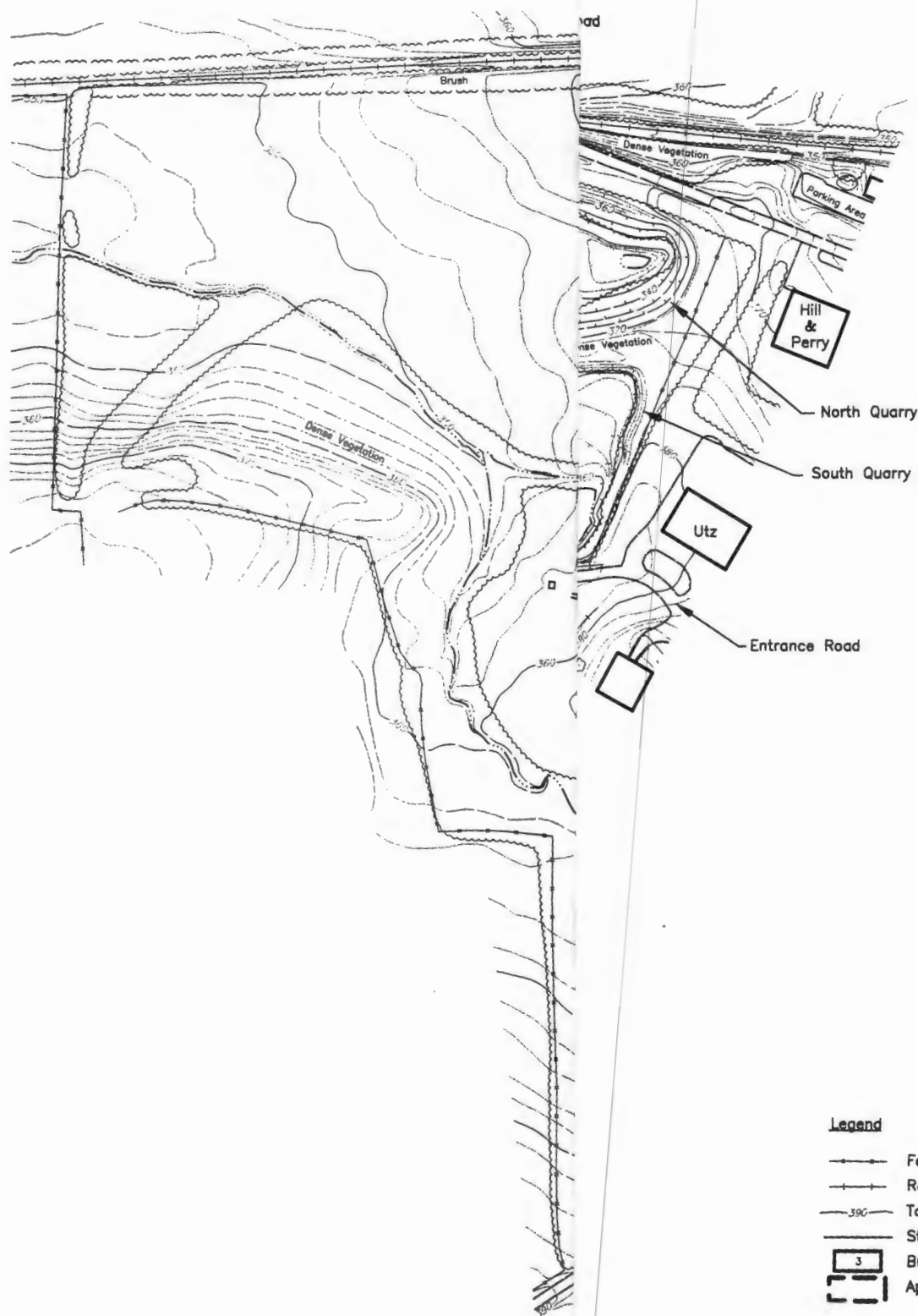
A research and development pilot plant on the premises produced various lithium chemicals in research quantities. Grinding and sizing operations were generally located south of an arc drawn from Building 27 to Building 8. The manufacturing of lithium chemicals was generally located in the central plant area. Building 17 housed strontium carbonate, lithium chloride, lithium fluoride and other lithium chemical operations, while Building 20 housed lithium bromide and other lithium chemical operations. Hexavalent chromium was used in both Building 17 and 20. Building 40 may also have housed some lithium chemical operations, but Building 17 and 20 were the site of the relatively high-volume, wet operations.

Figure 1-1
Site Location Map
Cyprus Foote Mineral Site
West Whiteland Township, PA



Source: Adapted from U.S.G.S. 7.5 Minute Series Topographic Maps, Malvern, PA (1983) Quadrangle

Figure 1-2 PFE ORIGINAL
Site Map
Cyprus Foote Mineral Site
West Whiteland Township, PA



Legend

- Fence
- Railroad
- Topographic Contour
- Stream
- Building
- Approximate Boundary Line

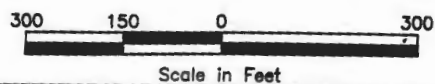


Table 1-1
Guidance Documents for RI/FS
Cyprus Foote Mineral Site
West Whiteland Township, PA

Reference Documents

- (1) Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA
US EPA/540/G-89/004
OSWER 9355.3-01
October 1988
 - (2) CERCLA Compliance with Other Laws Manual
US EPA/540/G-89/006
August 1988
 - (3) CERCLA Compliance with Other Laws Manual, Part II
Clean Air Act and Other Environmental Statutes and State Requirements
US EPA/540/G-89/009
OSWER Directive 9234.1-02
August 1989
 - (4) Risk Assessment Guidance for Superfund
Volume I: Human Health Evaluation Manual (Part A)
US EPA/540/1-89/002
December 1989
 - (5) Risk Assessment Guidance for Superfund
Volume II: Environmental Evaluation Manual
US EPA/540/1-89/001
March 1989
 - (6) Preparing Perfect Project Plans
A Pocket Guide for the Preparation of Quality Assurance Project Plans
US EPA Risk Reduction Engineering Laboratory
US EPA/600/9-89/087
October 1989
 - (7) Data Quality Objectives for Remedial Response Activities US EPA/540G-87/003
OSWER Directive 9355.0-7B
March 1987
 - (8) Developing a Work Scope for Ecological Assessments [ECO Update Vol. 1, No. 4]
Publication 9345.0051, May 1992
-

PFE ORIGINAL

Section 2

2.0

SUMMARY OF PRE-RI DATA

This section provides an overview of the pre-RI site investigations conducted at the Site. These investigations are part of the administrative record for the Site and are only referenced herein. The data from these pre-RI activities are summarized in the following sections. It should be noted that many of these activities were conducted using US EPA approved procedures, analytical parameters and guidelines in effect at that time. These investigations include work by US EPA and Weston.

Four soil sampling efforts were conducted at the Site by Weston from 1988 to 1992. The analytical results discussed in this section are tabulated in the following Weston reports:

- *Phase I Environmental Assessment* (Weston, September 1988; Section 4),
- *Phase II Preliminary Remedial Measures* (Weston, January 1989; Section 4),
- *Phase III Stage 2 Investigation of the North and South Quarries* (Weston, April 1992; Section 4), and
- *Phase III Stage 3 Investigation of Potential Soil Contamination Areas* (Weston, April 1992b; Section 4).

2.1

US EPA SITE INSPECTION

As part of the Hazard Ranking process, the US EPA collected 17 ground water, surface water, and sediment samples from the facility, and five ground water samples from off-site private wells in December 1987. The sample locations and analytical results generated from this site visit are presented in Appendix A of the report titled *Phase I Environmental Assessment of the Frazer Plant Site* (Weston, 1988) and are incorporated into this RI report by reference. These analytical results indicated production well, PW-2, contained detectable concentrations of total chromium, lithium, and trichloroethene (TCE). Volatile Organic Compounds (VOCs) were not detected in any other Site wells.

The (b) (6) domestic well, located at (b) (6) contained detectable concentrations of lithium and VOCs, specifically, toluene, ethylbenzene, and total xylenes. The VOCs detected in the (b) (6) domestic well are common constituents of petroleum hydrocarbon products. A potential source for these VOCs may be an oil spill or

pipeline leak that reportedly occurred on or near the 971 Swedesford Road property in or before 1953.

Surface water samples from the North and South Quarries were found to contain high levels of total chromium and lithium, respectively. Quarry fill samples from the North and South Quarries contained chromium, copper, lithium and zinc. The South Quarry fill sample also contained elevated concentrations of lead and mercury.

2.2

PHASE I ENVIRONMENTAL ASSESSMENT

Roy F. Weston, Inc. (Weston), West Chester, PA, conducted a series of site investigations to characterize soil and ground water at the Site. In April 1988, Weston conducted a Phase I Environmental Assessment (Phase I) at the facility, which focused on potential soil contamination in the quarries and at other Site locations.

During this assessment, the following areas were sampled:

- North and South Quarries;
- former Lithium Drum Cleaning Areas;
- three former Chromite Ore Storage Areas;
- farmed area west of the plant;
- former Solvent Burn Area;
- former Settling Pond Area; and
- former Colemanite (boron ore) Storage Area.

A total of 28 soil borings were drilled in the shallow and deep soil horizons of the above areas to evaluate the potential or extent of soil contamination at the facility. Surface water samples were taken from the North and South Quarries to determine the ponded surface water quality. The locations of the soil borings, the sampling methodologies, and the findings of this assessment were reported in *Phase I Environmental Assessment of the Frazer Plant Site* (Weston, September 1988).

2.3

PHASE II PRELIMINARY REMEDIAL MEASURES STUDY

In January 1989, Weston submitted a report titled *Draft Report, Preliminary Remedial Measures for the Frazer Plant Site* (Weston, January 1989). The

Preliminary Remedial Measures Study focused on the North and South Quarries and ground water. This phase of work is also referred to as the Phase II Investigation.

The Phase II scope of work was intended to provide data to develop preliminary remedial alternatives. This scope of work included:

- the completion of eight borings (three in the North Quarry and five in the South Quarry) to characterize the quality, engineering properties, and thickness of the quarry fill;
- the collection of eight hand-augured fill samples from the slopes of the North Quarry;
- the installation and sampling of seven bedrock monitoring wells to characterize ground water conditions in the carbonate bedrock aquifer beneath the Site; and
- the installation and sampling of eight overburden monitoring wells to characterize the perched water table in the quarry fill. Quarry fill samples were collected at selected depth intervals from each of the eight monitoring wells installed in the North and South Quarries.

2.4

PHASE III INVESTIGATION

During the period from December 1989 through April 1992, the Phase III Investigation was performed. The Phase III investigation focused on ground water conditions and potential remedial actions (Stage 1); conditions within the North and South Quarries and potential remedial actions (Stage 2); and investigation of additional areas which potentially contained impacted soils (Stage 3). The findings of these investigations were reported in the following documents: *Phase III-Stage 1 Ground Water Characterization and Remediation*, Cyprus Foote Mineral Company, Frazer, PA (Weston, November 1991); *Phase III-Stage 2 Investigation of the North and South Quarries*, Cyprus Foote Mineral Company, Frazer, PA (Weston, April 1992); *Phase III-Stage 3 Investigation of Potential Soil Contamination Areas*, Cyprus Foote Mineral Company, Frazer, PA (Weston, April 1992).

2.4.1

Phase III-Stage 1 Ground Water Characterization and Remediation

The purpose of the Phase III, Stage 1 investigation was to collect information to support the development of remedial alternatives for the previously identified areas of concern at the facility. During this investigation, 14 additional bedrock monitoring wells (MW-18 through MW-31) were installed and sampled to better characterize the ground

water quality. Ground water samples were analyzed for Hazardous Substance List (HSL) VOCs and metals. Samples were also analyzed for lithium, boron and hexavalent chromium. A preliminary fracture trace analysis, slug tests and a pumping test were conducted to gain a better understanding of the hydrogeologic conditions at the Site.

2.4.2 *Phase III-Stage 2 Investigation of the North and South Quarries*

The purpose of the Phase III, Stage 2 investigation was to characterize the condition of the North and South Quarries by surface sampling, drilling several soil borings, and installing additional monitoring wells. Soil and water samples were analyzed for HSL metals and VOCs. Selected soil samples were also analyzed for Extraction Procedure (EP) Toxicity metals, lithium, and boron. In addition, test pits were excavated on the western slope of the North Quarry to further characterize the soils. Selected soil samples from the test pits were analyzed for HSL metals, plus lithium, boron, and hexavalent chromium. Ground water samples from wells in the North and South Quarries were also analyzed for these parameters in addition to VOCs.

2.4.3 *Phase III-Stage 3 Investigation of Potential Soil Contamination Areas*

Shallow and deep soil samples were collected to investigate the soil conditions at the following on-site areas:

- former Settling Pond Area,
- former Wash Pond Area,
- former Septic System Area,
- former Solvent Burn Area,
- farm field area west of Building 52, and
- former Arsenite Disposal Area.

All soil samples collected were analyzed for HSL metals, plus lithium and boron. Selected soil samples were analyzed for hexavalent chromium, zirconium, and VOCs. Background soil samples were collected in a wooded area of the plant, assumed not to have been disturbed by plant activities, for comparison with the analytical results from soils collected at the areas listed above. Lithium and boron concentration ranges of natural soils in the Eastern United States were used for comparison purposes in the absence of regulatory guidelines.

2.5

REGIONAL GEOLOGY AND HYDROGEOLOGY

2.5.1

Regional Geology

The Site lies in the Piedmont Physiographic Province which is characterized by uplands comprised of igneous intrusive and metamorphic crystalline rocks which have weathered into rolling hills. In Chester County, these uplands are bisected by the Chester Valley, a prominent topographic feature which trends east-northeast. The Chester Valley is underlain mostly by Cambrian and Ordovician-age dolomites and limestones. The principal formations are the Ledger Dolomite, Elbrook Limestone, and Conestoga Limestone. The Chester Valley is bordered on the north and south primarily by crystalline igneous and metamorphic rocks (Sloto, 1987). Figure 2-1 depicts the regional geology of the area surrounding the Site.

The Chester Valley was formed of dolomites and limestones which were down-dropped by folding and faulting to form a narrow band of carbonates between the igneous and metamorphic crystalline rocks to the north and south. The geologic structure of the Chester Valley is comprised of a series of complicated synclines and anticlines which are often overturned to the north/northwest with both limbs frequently compressed together and dipping steeply to the south/southeast (CCPC, 1973). These folds trend northeast, approximately parallel to the Chester Valley. Major faults present in the valley may be normal, reverse, or thrust and trend parallel to the valley. Minor normal faults are also present and generally trend north or northeast (Sloto, 1987).

As is typical of carbonate rocks, some solution channels have formed in the limestones and dolomites within the valley by slow dissolution of the rock by naturally-occurring, weak carbonic and humic acids. These solution channels may extend over long distances and form sinkholes. Sinkholes have been reported in the Chester Valley northeast of the Site (CCPC, 1973).

The CFM Site lies within the central portion of the Chester Valley and is underlain mostly by the Cambrian-age Ledger Formation. The Ledger Formation is a pure, coarsely-crystalline dolomite which is light gray to blue, locally mottled, and massively bedded. The Elbrook Formation underlies a narrow strip of the farmed area at the extreme southwestern part of the Site, but is not exposed at the Site. It is a light-blue or cream-colored, impure, siliceous, often shaley limestone and is finely laminated, frequently with dolomite interbeddings. The Chickies Formation, a light-

gray, hard, massively-bedded quartzite, is present just north of the Site as a small knoll (Weston, 1988).

2.5.2 *Regional Hydrogeology*

The Ledger Dolomite underlying the Site is fine-grained with little primary porosity. Therefore, ground water occurrence in this formation is mostly in secondary porosity features such as solution channels, fractures, and open, weathered bedding planes. The Ledger generally yields small supplies of hard water due to its low primary porosity. However, large, water-filled solution channels and fractures can result in high yields to wells. Most wells in this formation yield from less than 1 gpm to 110 gpm, with the average reported yield being 22 gpm (Hall, 1973). Well yields in Chester County range from 0 to 1,125 gpm, with 50 percent of the wells producing at least 100 gpm. The Ledger Formation is hydraulically connected with adjacent units by a network of interconnected fractures and solution channels (Weston, 1991).

Ground water flow in this area of the valley is influenced by two active quarries, located approximately 2.5 miles northwest of the Site, which continually pump large quantities of ground water to keep the quarries dewatered. The Catanach Quarry and the Cedar Hollow Quarry, both of which mine dolomite and limestone from the Ledger and Elbrook Formations, are located along Route 29 south of Devault. The quarries are approximately 1,200 feet apart. In 1984, it was reported that the Cedar Hollow Quarry pumped an average of approximately 5 million gallons per day of ground water which was discharged to a tributary of Valley Creek (Sloto, 1987). The average pumpage from the Catanach Quarry is not known, but is assumed for the purposes of this report to be similar to the Cedar Hollow Quarry to achieve effective quarry dewatering.

As a result of these dewatering activities, a large cone of depression has developed around each quarry. The cone of depression around the Cedar Hollow Quarry is approximately 5,000 feet long and 2,000 feet wide; while the cone of depression around the Catanach Quarry is approximately 5,000 feet long and 3,500 feet wide. The Catanach Quarry discharges its pumpage to a closed surface depression between the two quarries which results in a ground water recharge mound (Sloto, 1987).

On a regional scale, pumping at the quarries results in an induced hydraulic gradient towards the quarries, along the strike of the Chester Valley. Structural features within the valley, such as bedding planes, formation contacts or fractures, act as controls which influence the flow patterns on a subregional scale.

Regionally, ground water flow in the Chester Valley is to the northeast, in the general direction of the Cedar Hollow and Catanach Quarries (Plate 2, Sloto, 1987). However, ground water in the vicinity of the Site does not appear to flow directly towards the Catanach Quarry (nearest to the Site), as there is a significant ground water divide located approximately 2,000 feet south of this quarry which trends parallel to the Chester Valley. This divide is caused by a ridge of Elbrook Limestone which is parallel to the quarries. The Elbrook in this area strikes east/northeast, which is parallel to the ridge and the quarries, and bedding is nearly vertical with dips measured at 70 degrees southeast. Because ground water movement in the Elbrook is principally through bedding planes and fractures, and is parallel to strike, ground water flow toward the quarries (that is, perpendicular to strike) is restricted (Sloto, 1987). This restriction in ground water flow is responsible for the ground water divide south of Catanach Quarry.

Superimposed upon this regional trend is the localized effect of pumping at miscellaneous production wells in the area. Two production wells operated by Philadelphia Suburban Water Company, which pump large quantities of water, are located immediately on or next to a prominent structural contact between the Ledger, Elbrook, and Chickies Formations.

This feature trends northeast, parallel to the strike of the Chester Valley, and is contiguous with the northern property boundary of the Site. One well (well identification CH-207) (b) (9) of the Site, pumps approximately 70 gallons per minute. The second well (well identification CH-2148) (b) (9) of the Site, pumps approximately 500 gallons per minute.

The cones of depression created by the pumping of high yield wells in the Ledger and Elbrook Formations are expected to be elliptical, with the long axis aligned parallel to the strike of the Chester Valley. The effect of this pumping activity is apparent in Figure 2-2 where water level measurements collected by the USGS in 1983 show an elongated cone of depression which trends northeast, parallel to the Chester Valley. The long axis of this cone of depression which contains the Site is coincidental with the structural contacts between the Ledger and Chickies Formations.

This is an important relationship for developing a conceptual understanding of the present ground water flow conditions within the Site vicinity. A pumping test conducted by Weston on Site well PW-3 created an elliptical cone of depression with the longitudinal axis parallel to the structural contact discussed above. Although this well was not

located on that predominant contact, it is located on a minor contact between the Ledger and the Elbrook to the south of the Site.

2.6

SITE SOILS, GEOLOGY, AND HYDROGEOLOGY

The surface soils in the Main Plant Area and North and South Quarries have been disturbed by quarrying and plant activities and are not representative of natural soil. The relatively undisturbed soils in the western portion of the Site, which have been farmed, have been mapped by the U.S. Soil Conservation Service as the following soils:

- Hagerstown silt loam,
- Croton silt loam, and
- Conestoga silt loam.

Soil samples observed below disturbed areas of the Site were typically orange, yellow-brown, red-brown and brown silty clays and clayey silts, with dolomitic and siliceous pebbles and cobbles. Gray, red, light-brown and orange mottles are present in some of the soils, especially in the area of the former Settling Ponds (Weston, 1991).

2.6.1

Site Geology

The Ledger Dolomite Formation underlies most of the Site and is characterized as tan-gray, white, and red-brown, fine-grained and dense, with some solution channels containing clay, sand, or silt. These solution channels can potentially be as much as 20 feet wide as observed in well MW-24. Depth to bedrock varies widely across the Site from 10 feet in well MW-4 to as much as 55 feet in well MW-29 (Weston, 1991).

Generally, the top of bedrock is highest in the southern portion of the Main Plant Area where a short bedrock ridge extends from approximately well MW-4 southwest to well MW-26. The depth to bedrock deepens north and northwest of this bedrock ridge. There are at least three isolated areas on site where depth to bedrock is greater than 40 feet; well MW-24, just west of the South Quarry; well MW-19, northeast of the concrete storage pads; and at wells MW-22 MW-29, in the former Solvent Burn Area. Additionally, depth to bedrock was reported to exceed 100 feet in a boring drilled along strike and east of well MW-22 (Weston, 1991). Figure 2-3 shows the locations of these wells.

Outcrops of Ledger dolomite are exposed in the North and South Quarries on the east side of the Site. Based on measurements obtained

from these outcrops, the Ledger Formation strikes N65-70 E beneath the Site and dips 48 to 65 degrees to the southeast. Fractures and solution openings are visible along the bedding planes of some South Quarry exposures. However, the older dolomite beds exposed in the North Quarry are more massive and less fractured and, therefore, less permeable than the beds in the South Quarry. The low permeability of the North Quarry dolomite is also evidenced by the low-yield of nearby monitoring wells. Wells MW-1, MW-6, and MW-7 all have yields on the order of 1 to 2 gallons per minute (gpm).

Historically, the North Quarry has been dry, whereas the South Quarry has contained ponded water (Weston, 1989). This is likely due to difference in the relative permeability of the fill materials in each quarry. It has been reported that miscellaneous debris was placed in the North Quarry while the South Quarry received primarily mineral tailings from plant operations. The debris likely provides preferential flow paths through the fill.

Multiple voids of undetermined horizontal extent are present in the limestone bedrock beneath the Site. Void spaces in the bedrock were identified in several monitoring wells in the Main Plant Area (MW-4, MW-5, and MW-19) as well as in all four wells located in the former Solvent Burn Area (MW-22, MW-29, MW-30, and MW-31). The void spaces were encountered at variable depths within each borehole and were reported to be filled with saturated clay or sand (Weston, 1991).

2.6.2 *Site Hydrogeology*

2.6.2.1 *Bedrock Aquifer*

Thirty-one monitoring wells were installed during the implementation of the previous investigations. Of these wells, 18 wells were installed in the bedrock. The bedrock aquifer wells are generally screened in the upper bedrock aquifer. Two monitoring wells (MW-8 and MW-17) were damaged and are not functional.

The direction of the hydraulic gradient beneath the Site varies with location. A water table map based on water level measurements recorded on 3 December 1990 is provided as Figure 2-4. Ground water in the vicinity of the quarries generally flows in a northeasterly direction, approximately parallel to the formation strike; however, just west of the quarries, ground water flows north. A ground water mound is present west of the South Quarry in the vicinity of wells MW-2 and MW-4. Ground water flows radially in a north, northeast, and northwest

direction away from the mound. The hydraulic gradient between well MW-4 and the (b) well, a private, off-site well located east of the North Quarry, was calculated at 0.008 (Weston 1989).

As part of the previous investigations, slug tests and a pumping test were conducted to estimate the hydrogeologic parameters of the bedrock aquifer beneath the Site (Weston, 1991). Slug tests were performed in 17 bedrock monitoring wells. A constant-rate pumping test was conducted by pumping production well PW-3 and monitoring water levels in all bedrock monitoring wells. The results of these tests are discussed in the Preliminary Remedial Investigation Report (ERM, 1994; Section 3).

2.7

SUMMARY OF ANALYTICAL DATA

The purpose of this section is to summarize the analytical results of the sampling conducted during the previous investigation phases. Samples of different environmental media were collected at the facility during the previous investigations, which were summarized above. Samples of surficial and subsurface soils, quarry fill material, ground water, surface water, and sediment were collected from the areas of concern, as well as from off-site locations, where applicable, to determine the presence or absence, concentrations, and distribution of site-related chemical constituents.

The soil data will be presented by area on the facility, rather than by investigative phase, to facilitate evaluation of the results. Ground water data for the Main Plant Area will be presented on a site-wide basis for the bedrock monitoring wells. However, data for the monitoring wells in the former Solvent Burn Area will be presented separately because of the potential presence of constituents of concern. The data for the quarry fill monitoring wells will also be presented separately from the site-wide ground water data because of the unique ground water conditions which are present within the quarries. The analytical results will be discussed and evaluated, as appropriate, in Sections 4, 5, and 6.

Four soil sampling efforts were conducted at the Site by Weston from 1988 to 1992. The analytical results discussed in this section are tabulated in the following Weston reports:

- *Phase I Environmental Assessment* (Weston, September 1988; Section 4),
- *Phase II Preliminary Remedial Measures* (Weston, January 1989; Section 4),

- *Phase III Stage 2 Investigation of the North and South Quarries* (Weston, April 1992; Section 4), and
- *Phase III Stage 3 Investigation of Potential Soil Contamination Areas* (Weston, April 1992b; Section 4).

The data tables included in this section summarize key constituent detections and are presented to facilitate the discussion of the data. The complete analytical data tables from the Weston reports have not been reproduced. Table 2-1 presents a summary of all pre-RI data illustrating those areas where RBCs were exceeded.

2.7.1 *North and South Quarries*

The surficial and subsurface fill materials in the North and South Quarries have been extensively sampled. Thirteen shallow (0 to 3 feet deep) fill samples and 23 subsurface (greater than 2 feet deep) fill samples were collected from the North Quarry during the three phases of the Weston investigation. Figure 2-5 shows the North Quarry sample locations. Eight shallow fill samples and 25 subsurface fill samples were collected from the South Quarry. Figure 2-6 shows the South Quarry sample locations. Two surficial soil samples (0 to 12 inch depth interval) were collected from the former Lithium Drum Cleaning Area, located on the southwest rim of the North Quarry, during Phase I. The two sample locations, Li-1 and Li-2, are shown on Figure 2-5.

2.7.1.1 *Inorganics - North Quarry*

The soil samples collected from the North Quarry were analyzed for inorganics, including HSL metals plus lithium and hexavalent chromium. Samples collected during Phase II, Phase III, and Stage 1 were also analyzed for boron. Tables 2-2a and 2-2b summarize the average and maximum inorganic concentrations detected in the North Quarry samples, and provide the location and depth of the sample containing the highest level of a given inorganic.

Cadmium, silver, and sodium were each detected in less than half of the 13 shallow fill samples (Table 2-2a). Selenium and thallium were not detected in the shallow fill samples. Sample AB-1, collected from 18 to 24 inches deep on the southwest side of the North Quarry, contained the maximum concentration of both chromium (840 mg/Kg) and hexavalent chromium (169 mg/Kg). The same sample also contained the highest concentration of arsenic (179 mg/Kg) in the shallow fill. Sample AB-2, collected from a depth of 24 to 30 inches on the southwest side of the

North Quarry, contained the maximum lithium concentration (1,160 mg/Kg). The six shallow fill samples collected during Phase II were analyzed for boron. The maximum boron concentration (410 mg/Kg) was detected in sample AB-6, at a depth of 5 to 8 inches.

Cadmium and silver were each detected in less than half of the 23 subsurface fill samples (Table 2-2b). Selenium and thallium were not detected in the subsurface samples. Subsurface fill samples collected from depths of 8 to 9 feet in test pits 1 and 13, on the southwest side of the North Quarry, contained the highest concentrations of eight metals: antimony, arsenic, barium, beryllium, chromium, hexavalent chromium, lead, and silver. Chromium and hexavalent chromium were detected at concentrations of 18,500 mg/Kg and 2,130 mg/Kg, respectively, in test pit 13. Lead was detected in test pit 13 at a concentration of 693 mg/Kg.

2.7.1.2 *Inorganics - South Quarry*

The soil samples collected from the South Quarry were analyzed for inorganics, including HSL metals plus lithium and hexavalent chromium. Samples collected during Phase II were also analyzed for boron. Tables 2-3a and 2-3b summarize the average and maximum inorganic concentrations detected in shallow and subsurface fill samples collected from the South Quarry, and provide the location and depth of the sample containing the highest level of a given inorganic. Six metals (cadmium, cobalt, potassium, selenium, silver, and thallium) were not detected in the shallow fill samples. Antimony was detected in only one shallow sample (SQ-4, 24 to 36 inches). Mercury and sodium were detected in less than half of the eight shallow fill samples. The shallow fill and subsurface fill samples were not analyzed for boron.

Shallow fill sample SQ-4, collected from a depth of 24 to 36 inches on the northwest side of the South Quarry, contained the highest concentrations of antimony, arsenic, barium, chromium, copper, iron, lead, magnesium, manganese, mercury, nickel, vanadium, and zinc. The maximum concentration of hexavalent chromium was detected in the shallow sample (0 to 12-inch depth interval) collected from SQ-5, on the southwest side of the South Quarry. The maximum lithium concentration was detected in the shallow sample (0 to 12-inch depth interval) collected from SQ-3, on the north side of the quarry.

Two metals, thallium and vanadium, were not detected in the subsurface fill samples. Six metals (antimony, barium, cadmium, cobalt, selenium, and silver) were detected in less than half of the subsurface fill samples. The subsurface fill samples in the South Quarry were all collected from

the five monitoring well borings advanced through the fill. MW-10, located near the middle of the South Quarry, and MW-11, on the northern side of the South Quarry, contained the highest levels of several metals. The sample collected (at a depth of 50 to 52 feet) from the bottom of the MW-10 boring, contained the maximum concentrations of six metals: cadmium, hexavalent chromium, cobalt, copper, manganese, and zinc. The sample collected (at a depth of 50 to 51.5 feet) from the bottom of the MW-11 boring, contained the maximum concentrations of seven metals: arsenic, barium, chromium, iron, potassium, silver, and sodium.

2.7.1.3 *Volatile Organic Compounds*

Eight samples of shallow fill were collected from the North Quarry during Phase I and analyzed for Hazardous Substance List (HSL) volatile organic compounds (VOCs). A summary of these analyses is included in Table 2-2a.

Eight samples of shallow fill were collected from the South Quarry during Phase I and analyzed for HSL VOCs. A summary of these analyses is included in Table 2-3a. VOCs were detected in all 8 samples. Six samples contained 2-hexanone, with a maximum concentration of 24 µg/Kg in SQ-5 (12 to 24 inches). All other detections of 2-hexanone were reported as estimated values below the method detection limit. Toluene was detected in three samples, with a maximum concentration of 11 µg/Kg in SQ-4 (24 to 36 inches). Three samples contained 1,1,1 trichloroethane, with a maximum estimated (below the detection limit) concentration of 7 µg/Kg in SQ-1 (0 to 4 inches) and SQ-5 (0 to 12 inches). Ethylbenzene was detected in one sample at an estimated value of 2 µg/Kg, and two samples contained 4-methyl-2-pentanone at the estimated concentration of 3 µg/Kg.

2.7.1.4 *Inorganics - EP Toxicity Results*

Eleven Phase II subsurface samples from the North Quarry and eight Phase II samples from the South Quarry were analyzed for 10 metals each by the EP Toxicity testing procedure. This testing was performed solely to evaluate potential leaching to ground water and not to make hazardous waste determinations.

The EP Toxicity results are presented on Table 2-4. Leachable levels of boron and lithium were detected in all of the samples analyzed from both quarries. Arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver were each detected in the leachate from at least one sample collected in the North or South Quarry. None of the North Quarry

samples contained leachable levels of cadmium, and no South Quarry samples contained leachable levels of silver.

Boron levels ranged from 4.26 milligrams per liter (mg/L) to 299 mg/L in leachate from samples from the North Quarry, and from 0.02 mg/L to 17.4 mg/L in the South Quarry samples. Lithium levels ranged from 1.40 mg/L to 3.13 mg/L in the North Quarry samples, and from 2.50 mg/L to 38.0 mg/L in samples from the South Quarry. Leachable levels of chromium were detected in four of the North Quarry samples, ranging from 0.10 mg/L to 0.33 mg/L, and in two of the South Quarry samples, at concentrations of 0.06 mg/L and 0.24 mg/L.

2.7.2 *Former Lithium Drum Cleaning Area*

The two surficial soil samples collected in the former Lithium Drum Cleaning Area, on the southwest rim of the North Quarry, were analyzed for lithium only. Sample Li-1, the northernmost sample, contained 4,390 mg/Kg lithium. Sample Li-2 contained 506 mg/Kg lithium.

2.7.3 *Main Plant Area*

Soil samples were collected from several sections of the Main Plant Area which were identified as potential soil contamination areas. Those areas included:

- former Septic System Area, near the eastern end of the Main Plant Area;
- three Chromite Ore Storage Areas in the Main Plant Area;
- former Wash Pond Area, in the northern part of the Main Plant Area; and
- Arsenite Disposal Area, on the western end of the Main Plant Area.

The analytical results for the soil sampling conducted in these areas are summarized in the following sections.

2.7.3.1 *Former Septic System Area*

Soil samples were collected from three borings (SB-9, SB-10, and SB-11) advanced in the former Septic System Area during the Phase III, Stage 3 investigation. The boring locations are shown on Figure 2-7. Sixteen soil samples were collected and analyzed for HSL VOCs, and 15 samples were analyzed for HSL metals plus hexavalent chromium, lithium, and boron.

Table 2-5 summarizes the average and maximum organic and inorganic concentrations detected in the soil samples collected in the former Septic System Area, and provides the location and depth at which the maximum concentration was detected. The only VOCs detected in the soil samples, which were not also present in the associated blank samples, were toluene and xylene (total), and concentrations for these constituents were reported as estimated levels, which were below the detection limits. Four soil samples (three from SB-9 and one from SB-10) contained toluene at an estimated concentration of 2 µg/Kg. Two samples contained xylene, at estimated concentrations of 1 µg/Kg (SB-9, 10 to 12 feet) and 4 µg/Kg (SB-9, 5 to 7 feet).

Of the 15 samples analyzed for HSL metals, only one, SB-9 (1-3'), was collected from a depth of less than 2 feet below the surface. The remaining 14 samples were collected at depths ranging from 2 feet to 27 feet. Selenium, silver, and thallium were not detected in any of the 15 samples. Sodium was detected in one of 15 samples. Antimony, cadmium, hexavalent chromium, mercury, and potassium were each detected in two samples. Boring SB-11, near the middle of the former Septic System Area, contained the maximum concentrations of 12 metals, in samples collected from varying depths in the boring. The highest concentrations of eight of those 12 metals were detected in a sample of fill material collected from the 2 to 4-foot depth interval in SB-11. The sample collected from 1 to 3 feet in boring SB-9 contained the maximum concentrations of six metals.

2.7.3.2

Chromite Ore Storage Areas

Shallow (less than 3 feet deep) soil samples were collected at the three Chromite Ore Storage Areas during the Phase I investigation. The locations of the three areas and the sample locations are shown on Figure 2-8. The samples were analyzed for chromium, hexavalent chromium, and boron. In addition, shallow and subsurface soil samples were collected from one soil boring advanced near each of the storage areas. Those samples were analyzed for the same metals plus lithium. These boring locations (B-2, B-3, and B-4) are also shown on Figure 2-8.

Table 2-6 summarizes the analytical results by storage area. None of the shallow or subsurface soil samples contained hexavalent chromium. The highest chromium and boron levels in both shallow and subsurface soils were detected in samples collected from the Chromite Ore Storage Area (Cr-1) south of Buildings 5 and 34, at the southern end of the Main Plant Area.

Lithium concentrations in shallow soils were highest in a sample from the area southwest of Building 27 (Cr-2), on the western side of the Main Plant Area. Lithium concentrations in subsurface soils were highest in samples collected in the area south of Building 52 (Cr-3), on the northwestern side of the Main Plant Area.

2.7.3.3

Former Wash Pond Area

One soil boring, SB-8, was advanced in the middle of the former Wash Pond Area, on the north side of the Main Plant Area, during the Phase III Stage 3 investigation. The boring location is shown on Figure 2-7. One shallow soil (0 to 2 feet deep) and five subsurface soil samples were collected and analyzed for HSL metals plus boron, hexavalent chromium, lithium, and zirconium. Two composite soil samples were collected from depths of 0 to 8 feet and 8 to 20 feet and analyzed for Toxicity Characteristic Leaching Procedure (TCLP) metals plus lithium and boron.

Table 2-7 summarizes the average and maximum inorganic concentrations detected in the shallow and subsurface soil samples from the Former Wash Ponds Area. Chromium concentrations ranged from 9.4 mg/Kg to 460 mg/Kg, with the highest levels detected in samples collected from 5 to 7 feet deep. Hexavalent chromium was detected in samples collected from 0 to 2 feet and 5 to 7 feet deep, at concentrations of 0.12 mg/Kg and 0.37 mg/Kg, respectively. Lithium concentrations ranged from none detected in the two deepest samples to 72.8 mg/Kg in the shallow soil sample. Boron concentrations ranged from 22 mg/Kg to 525 mg/Kg, with the highest levels detected in samples from 5 to 7 feet deep.

Boron, barium, and lithium were detected in the TCLP leachate from both of the composite samples collected from the former Wash Pond Area. Boron concentrations were 2,770 micrograms per liter ($\mu\text{g/L}$) (0 to 8 feet) and 2,020 $\mu\text{g/L}$ (8 to 20 feet). Barium levels were 397 $\mu\text{g/L}$ in the shallower sample and 18,600 $\mu\text{g/L}$ in the deeper sample. Lithium concentrations were 374 $\mu\text{g/L}$ (0 to 8 feet) and 327 $\mu\text{g/L}$ (8 to 20 feet). The TCLP leachate of the sample collected from 8 to 20 feet also contained 19.9 $\mu\text{g/L}$ of chromium and 315 $\mu\text{g/L}$ of selenium.

2.7.3.4

Arsenite Disposal Area

Soil samples were collected from two locations in the Arsenite Disposal Area during the Phase III Stage 3 investigation (1990), shown as HA-7 and HA-8 on Figure 2-7. Two samples were collected from each location, with a maximum sample depth of approximately 6 feet below the surface. The

samples were analyzed for HSL metals plus hexavalent chromium, lithium, boron, and zirconium. Two additional samples were analyzed for the TCLP metals plus lithium and boron.

Table 2-8 summarizes the average and maximum inorganic concentrations detected in soil samples collected in the Arsenite Disposal Area. Lithium was detected in two samples at 28.3 mg/Kg and 30.6 mg/Kg. Chromium was detected in all four samples, ranging from 14.7 mg/Kg to 40.2 mg/Kg. Arsenic was detected in two samples, at concentrations of 219 mg/Kg and 10.5 mg/Kg. Lead was present in all four samples, ranging from 11.6 mg/Kg to 33.7 mg/Kg. No other metals were detected.

Barium and lithium were detected in the TCLP leachate from both samples. Lithium concentrations were 383 µg/L and 47.4 µg/L. Barium levels were 669 µg/L and 47.4 µg/L. Boron was detected in the TCLP leachate from one sample, at a concentration of 204 µg/L.

In March 1992, Consulting Services, Inc. (CSI) excavated approximately 70 tons of soil impacted by low concentrations of arsenic from the Arsenite Disposal Area. These soils were transported off-site to a commercial disposal facility. Post excavation samples were obtained in June 1992 to confirm the excavation of arsenic-impacted soil. Except for one sample (out of 12 collected), arsenic was not detected above 10 mg/Kg. Arsenic was detected in one sample at a concentration of 537 mg/Kg.

Additional excavation activities were conducted in August 1992 to remove soil from the one elevated sample location. Arsenic was detected in two post-excavation samples at concentrations of 24 mg/Kg and 13 mg/Kg.

2.7.3.5

Former Solvent Burn Area

One soil boring, B-1, was advanced in the former Solvent Burn Area during the Phase I investigation. The boring location is shown on Figure 2-8. One shallow soil (0 to 2 feet deep) sample and four subsurface soil samples were collected and analyzed for HSL VOCs and lithium. Six test pits were excavated in the area during Phase III, Stage 3, at the locations shown on Figure 2-7, and four soil samples were collected. Two soil samples, TP-24-1 and TP-24-3, were analyzed for HSL VOCs, and two soil samples, TP-24-3 and TP-24-4, were analyzed for HSL metals plus boron, hexavalent chromium, and lithium. Table 2-9 summarizes the average and maximum inorganic and organic concentrations detected in soil samples collected from the former Solvent Burn Area.

Volatile Organic Compounds

The only VOC detected in the soil samples collected from the Phase I soil boring was trichloroethene, at a concentration of 3 µg/Kg.

Trichloroethene was also present in the associated blank. Test pit soil sample, TP-24-1, collected from a depth of 17 feet, contained toluene and chlorobenzene at estimated concentrations of 3 µg/Kg and 2 µg/Kg, respectively. Test pit soil sample, TP-24-3, collected from a depth of 6 feet, contained trichloroethene at an estimated concentration of 5 µg/Kg, and tetrachloroethene at a concentration of 10 µg/Kg.

Inorganics

Lithium concentrations ranged from non-detected in two subsurface soil samples (B-1 at 2 to 4 feet and TP-24-4) to 45 mg/Kg in test pit sample TP-24-3, collected at a depth of 14 feet. Chromium was detected in the two test pit soil samples at concentrations of 15.2 mg/Kg and 25.7 mg/Kg. Hexavalent chromium was not detected in either of the two test pit soil samples. Boron was detected in test pit soil sample TP-24-3 at a concentration of 28.7 mg/Kg.

2.7.3.6

Former Settling Pond Area

The shallow and subsurface soils in the former Settling Pond Area were extensively sampled during the Phase I and Phase III investigations. There were 15 shallow (0 to 3-foot depth interval) and 26 subsurface soil samples collected from the former settling ponds. The surficial sample and soil boring locations are shown on Figures 2-7 and 2-8. Seven shallow and eight subsurface Phase I soil samples were analyzed for HSL VOCs. Those samples, plus an additional two subsurface soil samples, were also analyzed for HSL metals. Selected Phase I soil samples were analyzed for lithium and boron. The Phase III soil samples (eight shallow and 16 subsurface) were analyzed for HSL metals plus boron, hexavalent chromium and lithium. Four composite soil samples were collected in the former Settling Pond Area and analyzed for TCLP metals plus lithium and boron. Soils from the following depth intervals: 0 to 3 feet, 3 to 7 feet, 10 to 12 feet, and 15 to 22 feet; were composited from four locations.

Volatile Organic Compounds

All VOCs detected in the shallow soil samples (0 to 3-foot depth interval) were also present in the associated blanks. Half of the reported value for each sample was used in calculating the average VOC concentrations given in Table 2-10a. Table 2-10b shows that subsurface soil samples

contained methylene chloride at concentrations ranging from non-detect to 10 µg/Kg. Acetone was detected at concentrations ranging from non-detect to 19 µg/Kg.

Inorganics

Included in Tables 2-10a and 2-10b is a summary of the average and maximum inorganic concentrations detected in shallow and subsurface soil samples from the former Settling Pond Area, and the location and depth of the sample containing the highest level of a given constituent. Antimony, boron, cadmium, cobalt, mercury, potassium, silver, and thallium were detected in less than half of the shallow soil samples. Selenium and sodium were not detected in any of the shallow samples. Three metals (mercury, selenium, and silver) were not detected in any of the subsurface soil samples. Antimony, arsenic, boron, cadmium, calcium, hexavalent chromium, magnesium, potassium, sodium and thallium were detected in less than half of the subsurface soil samples.

The shallow sample collected from SB-1, near the southwestern end of the middle Settling Pond Area, contained the highest concentrations of nine metals: barium, boron, cadmium, cobalt, copper, manganese, nickel, vanadium, and zinc. The subsurface soil sample collected at location B-6 from a depth of 5 to 7 feet, near the west end of the eastern settling pond, contained the highest concentrations of eight metals: arsenic, barium, boron, chromium, copper, magnesium, manganese, and nickel.

Table 2-11 indicates that barium and lithium were detected in the TCLP leachate from four of the composite samples collected. Barium concentrations ranged from 256 µg/L (in the composite from 20 to 22 feet) to 823 µg/L (in the composite from 0 to 3 feet). Lithium concentrations ranged from 39.4 µg/L (20 to 22 feet) to 2,230 µg/L (3 to 8 feet). Leachable levels of boron were detected in the samples composited from 3 to 8 feet (249 µg/L) and 10 to 12 feet (156 µg/L). Cadmium was detected in the leachate of the samples from 0 to 3 feet (29.7 µg/L) and 15 to 17 feet (6.2 µg/L). Leachable chromium was detected in the samples from 0 to 3 feet (357 µg/L) and 3 to 8 feet (21.2 µg/L). Lead was detected in the leachate of the 0 to 3 foot-sample at a concentration of 813 µg/L (1,420 µg/L in a duplicate sample).

2.7.3.7

Former Colemanite (Boron Ore) Storage Area

One soil boring, B-5, was advanced in the former Colemanite Storage Area, located south of the former Settling Ponds Area, during the Phase I investigation. The boring location is shown on Figure 2-8. One shallow

soil (0 to 2-foot depth interval) and four subsurface soil samples were collected and analyzed for boron and lithium.

Boron concentrations ranged from 77 mg/Kg to 229 mg/Kg. The highest concentration was detected in the sample collected from the 2 to 4 foot depth interval. Lithium concentrations ranged from 24.8 mg/Kg to 35.2 mg/Kg, with the highest level detected in the sample from 4 to 6 feet deep.

2.7.3.8 *Background Soils West of Plant*

The farm fields west of the main plant and the area west of Valley Creek are considered to represent background areas on the Site. The shallow soils in these areas are not expected to have been impacted by Site activities. Shallow soil samples were collected from seven locations (No. 1, and No. 3 through 8 shown on Figure 2-8) in the farm field area during the Phase I investigation. Seven samples were collected from depths of 0 to 12 inches, and five samples were collected from 12 inches to a maximum depth of 36 inches. One other Phase I sample location from the farm field area, No. 2 on Figure 2-8, was not included with the background soils because the concentrations of several metals (arsenic, beryllium, cobalt, manganese, and zinc) were elevated above the concentrations in the other samples, and this area may receive runoff from the Site.

Three shallow background soil samples (HA-9, HA-10, and HA-11) were collected from depths of 6 to 8 inches in the area west of Valley Creek during the Phase III, Stage 3 investigation. These sample locations are shown on Figure 2-7. Samples were also collected from six additional locations in the farm field area during the Phase III, Stage 3 investigation. Those locations are shown as HA-1 through HA-6 on Figure 2-7.

The Phase I background soil samples were analyzed for HSL VOCs. No VOCs were detected in the shallow background soils.

The background soil samples from both areas were analyzed for HSL metals. The Phase III samples were also analyzed for boron, hexavalent chromium, lithium, and zirconium. Table 2-12 summarizes the maximum concentrations detected in the background soils collected from the farm field area during Phase I and from the area west of Valley Creek during Phase III, Stage 3. The observed ranges and mean concentrations for metals in eastern United States surficial soils (Shacklette and Boerngen, 1984) are also listed on Table 2-12 for comparison with site-specific data. The samples collected from the farm field area during Phase III are not

included on Table 2-12 since those samples were collected near previous Phase I sample locations, and the data are generally consistent with Phase I data. Also, the Phase III locations were closer to some of the potential source areas, such as the former Solvent Burn Area and the Arsenite Disposal Area, than the earlier background samples.

Boron, hexavalent chromium, lithium, and zirconium were not detected in the three background soil samples collected west of Valley Creek. Selenium, silver, and thallium were not detected in any of the shallow background soils. Antimony, cadmium and mercury were only detected in background soil samples collected west of Valley Creek, whereas potassium and sodium were only detected in background soil samples collected in the farm field area.

2.7.4

Ground Water

Thirty-one monitoring wells were installed at the Site by Weston; however, two wells, MW-8 and MW-17 were damaged and not functional. The monitoring well locations are shown on Figure 2-3. Fifteen monitoring wells were installed during the Phase II investigation, including eight quarry fill monitoring wells (MW-9 through MW-16) and seven bedrock monitoring wells across the plant area (MW-1 through MW-7). Fourteen bedrock monitoring wells (MW-18 through MW-31) were installed during the Phase III investigation to provide additional data across the Site. Most of the Phase III monitoring wells were installed in the western and southern portions of the Site.

The ground water analytical results are tabulated in the following Weston reports:

- *Phase I Environmental Assessment* (Weston, September 1988; Section 2),
- *Phase II Draft Preliminary Remedial Measures* (Weston, January 1989; Section 4),
- *Phase III Stage 1 Ground Water Characterization and Remediation* (Weston, November 1991; Section 4), and
- *Phase III Stage 2 Investigation of the North and South Quarries* (Weston, April 1992a; Section 4).

The data tables included in this section summarize key site constituent detections which are presented to facilitate the discussion of the data. The complete analytical data tables from the Weston reports have not been reproduced.

For the purpose of discussion, the ground water data have been summarized in four subsets:

- the quarry monitoring wells, screened in quarry fill;
- the site-wide monitoring wells, screened (or open holes) in bedrock;
- the former Solvent Burn Area monitoring wells; and
- the off-site residential and public water supply wells.

2.7.4.1

North and South Quarry Monitoring Wells

Three monitoring wells were installed with their screened intervals in the North Quarry fill (MW-14 through MW-16), and five monitoring wells were screened in the South Quarry fill (MW-9 through MW-13). Ground water samples were collected from the quarry area monitoring wells during the Phase II and Phase III investigations. The samples were analyzed for HSL VOCs, hexavalent chromium, and dissolved HSL metals plus boron and lithium. Two South Quarry monitoring wells, MW-10 and MW-12, were not sampled during the Phase III sampling event because they were submerged below ponded water in the Quarry.

Volatile Organics Results

VOCs were detected in two North Quarry monitoring wells, MW-16 and MW-15, during the Phase II ground water sampling. Methylene chloride and acetone were detected in MW-16 at concentrations of 11 µg/L and 34 µg/L, respectively. Benzene and toluene were also present in MW-16, both at estimated concentrations (below quantitation limits) of 3 µg/L. Well MW-15 contained methylene chloride at a concentration of 6 µg/L. No VOCs were detected above quantitation limits in the North Quarry monitoring well, MW-14, during the Phase II ground water sampling. No VOCs were detected in the three North Quarry monitoring wells during the Phase III ground water sampling.

No VOCs were detected in the South Quarry monitoring wells during the Phase II ground water sampling. Acetone was detected in three South Quarry monitoring wells during the Phase III sampling: MW-9, MW-11, and MW-13, at concentrations ranging from 38 to 100 µg/L. Carbon tetrachloride was detected in MW-9 and MW-11, at a concentration of 5 µg/L in both wells. Toluene was present in MW-11 at a concentration of 12 µg/L.

Inorganics

Table 2-13 summarizes the ground water analytical results for boron, chromium, hexavalent chromium, and lithium for the Phase II (December 1988) and Phase III (March 1990) ground water sampling of the quarry fill monitoring wells. The data presented in Table 2-13 are for dissolved metals (samples were field filtered), except for hexavalent chromium.

Boron and lithium were detected in the Phase II and Phase III sampling of the three North Quarry monitoring wells. Chromium and hexavalent chromium were detected in MW-15 during both rounds of sampling, and in MW-16 during the Phase III sampling. Other trace metals detected in the North Quarry monitoring wells during the Phase III ground water sampling included antimony (ND to 784 µg/L), lead (ND to 19 µg/L), manganese (ND to 732 µg/L), and zinc (ND to 55.2 µg/L).

Lithium was detected in each of the South Quarry monitoring wells sampled during Phase II and Phase III. Boron was detected in three Phase II samples (MW-9, MW-11, and MW-13). Boron data were not reported for MW-10 and MW-12 in the Phase II report (Weston, 1989). Boron was detected in one monitoring well, MW-9, in the Phase III sampling. Chromium and hexavalent chromium concentrations were detected in two monitoring wells, MW-9 and MW-13, during the Phase III sampling; however, chromium was not detected in the Phase II samples from those wells. Metals detected in the Phase III samples from the South Quarry monitoring wells included barium (281 to 485 µg/L), lead (5.0 to 9.4 µg/L), vanadium (51.5 to 53.7 µg/L), and zinc (ND to 114 µg/L).

2.7.4.2

Site-Wide Bedrock Monitoring Wells

The bedrock monitoring wells located on site have been sampled during three investigations.

- Two on-site production wells, PW-2 and PW-3, were sampled and analyzed for VOCs, semivolatile organics, and metals during the 1987 USEPA site inspection conducted by NUS Corporation. The results of the NUS sampling are summarized in the Weston Phase I report.
- Ground water samples were collected from seven bedrock monitoring wells in December 1988, during the Phase II investigation, and analyzed for HSL VOCs, hexavalent chromium, and dissolved HSL metals plus boron and lithium.
- Samples were collected from 19 bedrock wells: 17 site-wide monitoring wells plus two on-site pumping wells, during the Phase

III ground water sampling. The Phase III samples were analyzed for HSL VOCs, hexavalent chromium, and dissolved HSL metals plus boron and lithium.

Data for four additional bedrock monitoring wells (MW-22, 29, 30, and 31), located in the former Solvent Burn Area, are discussed in Section 2.7.4.3.

Volatile Organics

Trichloroethene (TCE) was detected in production well PW-2, located in the middle of the Main Plant Area, at a concentration of 50 µg/L during the 1987 NUS sampling event. No VOCs were detected in PW-3, located on the southwest side of the Site, during the 1987 sampling. No semivolatile organic compounds were detected in either on-site production well.

VOCs were detected in three bedrock monitoring wells during the Phase II ground water sampling. Well MW-5 contained 82 µg/L of TCE and 13 µg/L of 1,2-dichloroethene (total). Well MW-4 contained 18 µg/L of chloroform. Methylene chloride was detected in the sample from MW-2 at a concentration of 5 µg/L. No other VOCs were detected in the Phase II ground water samples.

Table 2-14 summarizes the analytical results for VOCs for samples collected during the Phase III ground water sampling. The wells are grouped on Table 2-14 according to their general locations on the Site. VOCs were detected in 10 monitoring wells during the Phase III sampling. Total VOC concentrations ranged between an estimated concentration of 2 µg/L in MW-28 and 474 µg/L in MW-18. TCE was the most common VOC detected, and was present in five wells located in the central part of the Main Plant Area. The TCE concentrations ranged between 1 µg/L (MW-19) to 420 µg/L (MW-18). In two of the five wells, MW-5 and MW-18, 1,2 dichloroethene was also detected at concentrations of 10 µg/L and 33 µg/L, respectively. Nine wells contained no VOCs: MW-2, MW-3, MW-20, MW-21, MW-26, MW-27, and PW-3.

Inorganics

Table 2-15 summarizes the inorganic detections for the Phase III ground water sampling. The data shown are for dissolved metals (field filtered samples), with the exception of hexavalent chromium. Boron was detected in all of the bedrock wells, at concentrations ranging from 113 µg/L in MW-1 to 33,100 µg/L in MW-21. Lithium was detected in 17

wells, at concentrations ranging from 115 µg/L in MW-3 to 90,400 µg/L in PW-2. Lithium was not detected in MW-23 or PW-3, on the southwest side of the plant. Chromium was detected in 15 wells; 12 of those wells also contained hexavalent chromium. Other trace metals detected in the Phase III samples from one or more bedrock monitoring wells include arsenic, lead, manganese, mercury, selenium, and zinc.

2.7.4.3

Former Solvent Burn Area

One bedrock monitoring well, MW-22, was installed in the former Solvent Burn Area in January 1990. The well was sampled and analyzed for HSL VOCs in May 1990 and August 1990. The May 1990 sample from MW-22 was also analyzed for hexavalent chromium and dissolved HSL metals plus boron and lithium. Three additional monitoring wells (MW-29, MW-30, and MW-31) were installed in December 1990. Monitoring wells MW-22, MW-29, MW-30, and MW-31 were sampled in December 1990 and analyzed for HSL VOCs. The December 1990 ground water samples were also analyzed for dissolved boron, lithium, calcium, and magnesium.

Volatile Organics

Total VOCs were detected in monitoring well MW-22 at concentrations of 6,861 µg/L and 5,552 µg/L in the May 1990 and August 1990 sampling events, respectively. The predominant VOCs detected were benzene (5,300 µg/L and 4,200 µg/L, respectively) and PCE (1,400 µg/L and 1,300 µg/L, respectively). Other VOCs detected in the initial sampling of MW 22 include: 1,2-dichloroethane, 1,2-dichloroethene, toluene, TCE, and xylenes.

PCE was the only VOC detected in the December 1990 sample from MW-22 at a concentration of 120 µg/L. PCE was also detected in MW-29 and MW-31, at concentrations of 12 µg/L and 8 µg/L, respectively. The only other VOCs detected during the December 1990 sampling were TCE in MW-30, at an estimated concentration of 31 µg/L, and xylenes in MW-29 and MW-30, at estimated concentrations of 1 µg/L and 2 µg/L, respectively.

Inorganics

In the May 1990 ground water sampling event, boron and lithium were detected in monitoring well MW-22 at concentrations of 33,000 µg/L, and 96,600 µg/L respectively. Boron and lithium were detected in the four monitoring wells sampled in the December 1990 sampling event. Boron

concentrations ranged from 444 µg/L to 4,470 µg/L. Lithium concentrations ranged from 202 µg/L to 16,800 µg/L. MW-22 contained the highest boron and lithium concentrations, and MW-30 contained the lowest boron and lithium concentrations. Other trace metals detected in MW-22 in May 1990 included arsenic (51.4 µg/L), manganese (41.5 µg/L), and vanadium (58.9 µg/L).

2.7.4.4

Off-Site Wells

There are a number of residential wells in the Site vicinity, and the Philadelphia Suburban Water Company (PSWC) operates a public water supply well (b) (9). The locations of selected off-site wells for which analytical data are available are shown on Figure 2-9.

Foote Mineral Company collected water samples quarterly from five area wells, including the PSWC well and four residential wells ((b) (6) (b) (6), and (b) (6) shown on Figure 2-9), from 1972 through 1990. The samples were only analyzed for lithium. Pursuant to the SDWA/ Administrative Order on Consent CFM: (1) conducted a water well survey to identify all wells located within a specified off-site area; (2) analyzed certain wells for lithium, chromium and boron; (3) provided an alternative permanent water supply for one household; and (4) conducted an annual monitoring program of six residential wells for boron, and lithium. NUS Corporation collected samples from five wells near the Site during the 1987 USEPA site inspection, and the samples were analyzed for VOCs, semivolatiles, and metals. The locations of the PSWC well, the wells sampled by CFM under the Administrative Order on Consent ((b) (6) (b) (6)), and the wells sampled by NUS (NUS1, NUS2, NUS4 (b) (6) and PECO) are shown on Figure 2-9.

Additionally, the United States Geological Survey (USGS) summarized historical analytical data for samples collected from selected wells in Chester County (Sloto, 1989). This report included data for samples collected from the PSWC well in 1984 and 1985.

The ground water data for off-site well sampling are summarized from the following reports:

- *Phase I Environmental Assessment* (Weston, September 1988; Section 4),
- *Phase III Stage 1 Ground Water Characterization and Remediation* (Weston, November 1991; Section 4), and

- Sloto, Ronald A., 1989. *Selected Ground Water Data, Chester County, Pennsylvania* (Sloto, 1989, USGS Open-File Report 87-217).

Data for the period 1972 through 1990 were obtained from Foote Mineral Company's files.

Volatile Organics

Analytical data for samples collected from the PSWC well in 1984 and 1985 and analyzed for volatile organics were reported in Sloto (1989). The only VOCs detected in the PSWC well were TCE and PCE. TCE was detected in the 1984 and 1985 samples, at concentrations of 18 µg/L and 12 µg/L, respectively. The 1984 sample also contained 8 µg/L of PCE.

The sample collected by NUS in 1987 from the (b) (9) well, contained toluene, ethylbenzene, and xylenes at a total concentration of 323 µg/L. This well also contained 10 µg/L of naphthalene. The 1987 sample collected by NUS from a well located on the Philadelphia Electric Company property (southwest of the main plant) contained 5 µg/L of 1,1,1-trichloroethane. No organics were detected in the other off-site wells sampled by NUS in 1987.

Inorganics

Lithium concentrations in the 1984 and 1985 USGS samples from the PSWC well were 850 µg/L and 930 µg/L, respectively (Sloto, 1989). Foote Mineral Company files indicate that lithium concentrations in the PSWC well have ranged from approximately 500 µg/L to 2,000 µg/L. The highest concentrations were detected in samples collected during the 1970s. Lithium concentrations in samples collected by CFM from 1990 through 1993 ranged from 890 µg/L to 920 µg/L. Boron concentrations in the PSWC well since 1990 ranged from 260 µg/L to 310 µg/L. The 1984 USGS sample contained 200 µg/L of boron. Chromium concentrations, measured from 1981 through 1991 ranged from 1 µg/L to 63 µg/L.

Two residential wells, (b) (9) on the (b) (9), historically contained the highest lithium and boron concentrations out of the off-site wells near the Site. Lithium concentrations in the (b) (9) well have ranged between 8,000 µg/L to 22,000 µg/L, with a range of 14,900 µg/L to 15,200 µg/L from 1991 through 1993. Historical lithium concentrations in the (b) (9) well have ranged from 2,000 µg/L to 7,500 µg/L, with concentrations of 4,560 µg/L and 5,220 µg/L in 1992 and 1993, respectively. The (b) (9) well was the

only one of the five off-site wells sampled by NUS in 1987 that contained lithium (2,850 µg/L). NUS did not sample the (b) (9) well.

Boron concentrations in the (b) (9) well ranged from 9,440 µg/L to 11,000 µg/L during the period from 1991 through 1993. Boron concentrations in the (b) (9) well were 3,650 µg/L and 3,840 µg/L in 1992 and 1993, respectively. Chromium concentrations in the (b) (9) well, measured since 1981, ranged from 1 µg/L to 200 µg/L; however, the concentrations have been less than 20 µg/L since 1985. Chromium concentrations in the (b) (9) well have historically been less than 10 µg/L.

2.7.5 *Surface Water and Sediment*

2.7.5.1 *On-Site Surface Water and Sediment*

NUS Corporation collected two surface water and two sediment samples from the portion of Valley Creek which traverses the western part of the Site, during the 1987 site inspection conducted for USEPA. The sample locations (Figure 4-6 of *Preliminary Remedial Investigation Report and Work Plan for Completion of the Remedial Investigation, Feasibility Study and Risk Assessment*, ERM, Nov. 1994) were upstream (NUS 7) from and downstream (NUS 8) from the discharge of the on-site wastewater treatment plant. Surface water and sediment samples were analyzed for VOCs, semivolatile organic compounds (SVOCs), and metals, including lithium.

No VOCs or SVOCs were detected in the two surface water samples. Lithium was detected in the downstream sample at a concentration of 438 µg/L. Lithium was not detected in the upstream sample. Chromium was not detected in either sample. The samples were not analyzed for boron.

No VOCs were detected in the two sediment samples. Both samples contained SVOCs, with total concentrations of 7,129 µg/Kg in the upstream sample and 6,829 µg/Kg in the downstream sample. Polynuclear aromatic hydrocarbons (PAHs) were the predominant SVOCs detected in each sample.

Lithium was detected in both sediment samples at concentrations of 20 mg/Kg in the upstream sample, and 28 mg/Kg in the downstream sample. Chromium concentrations were 20.5 mg/Kg (upstream) and 20.3 mg/Kg (downstream). Lead was detected in both samples at estimated concentrations of 96.5 mg/Kg in the upstream sample, and 129 mg/Kg in the downstream sample.

2.7.5.2

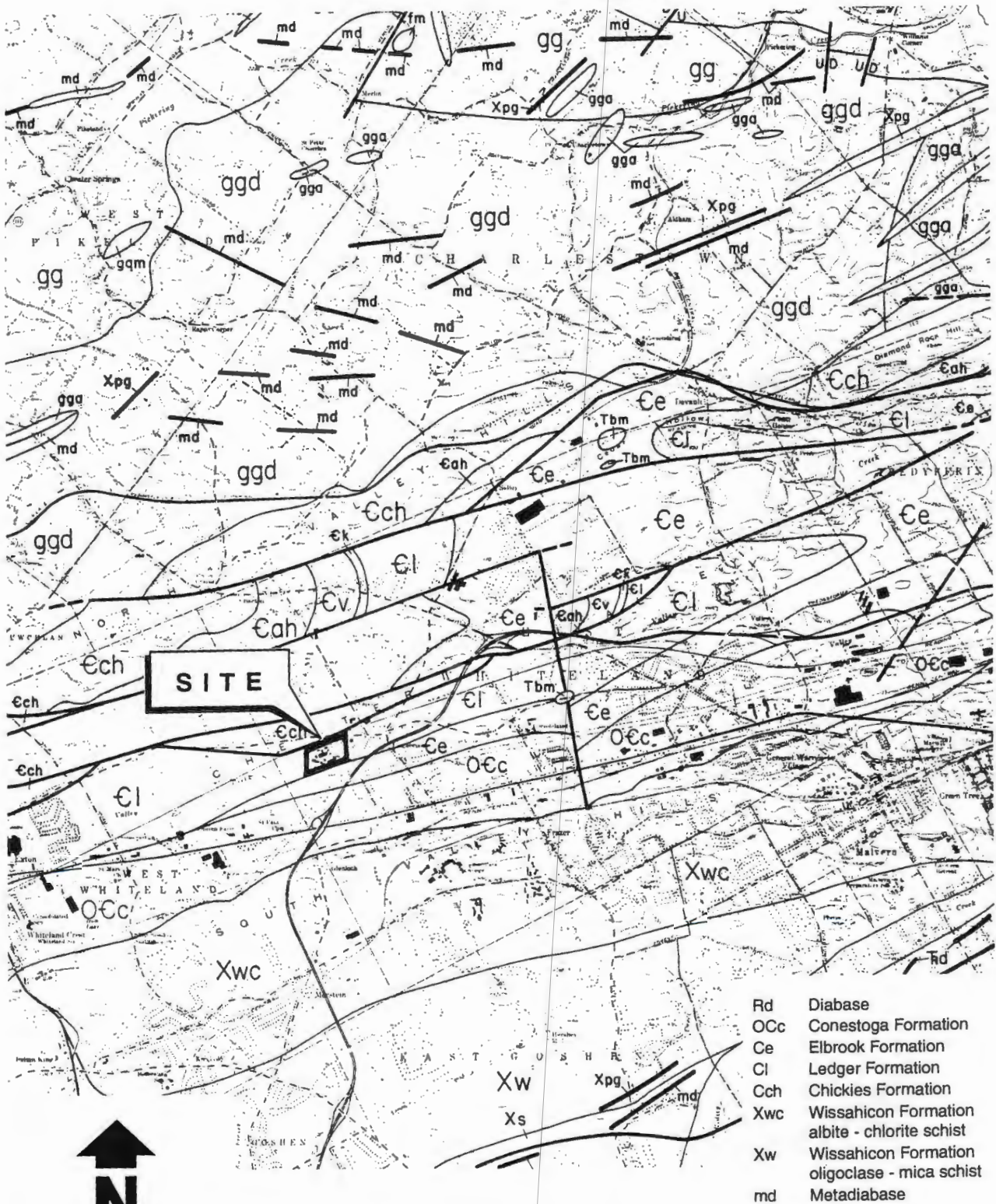
Off-Site Surface Water

The USGS collected surface water samples from the Valley Creek east of the Site and its tributaries (Sloto, 1987). Samples were collected at nine locations in the Site vicinity during October 1984, and from one additional location in March 1985. The sample locations are shown on Figure 2-10. The samples were analyzed for dissolved boron and lithium. The data are summarized in Table 2-16. Boron was detected in samples A3 through A10, at concentrations ranging from 30 $\mu\text{g/L}$ to 130 $\mu\text{g/L}$. Lithium was detected in samples A3 through A5, and A7 through A8, at concentrations ranging from 10 $\mu\text{g/L}$ to 780 $\mu\text{g/L}$.

The USGS also collected monthly base flow water samples from location A7 on the Valley Creek, approximately 1.9 miles northeast of the Site, from March through December 1984 (Sloto, 1987). Samples collected from March through August 1984 were analyzed for dissolved lithium; the remaining samples were analyzed for dissolved lithium and boron. Those data are also shown on Table 2-16. Boron and lithium concentrations were directly proportional to each other. Data also showed that lithium and boron concentrations were inversely related to discharge rate; that is, concentrations increased as discharge decreased.

Figure 2-1
Regional Geologic Map
Cyprus Foote Mineral Site
West Whiteland Township, PA

PFE ORIGINAL



Adapted from: Atlas of Preliminary Geologic Quadrangle Maps of Pennsylvania,
 Pennsylvania Topographic and Geologic Survey, 1981